

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Kingman County, Kansas

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In cooperation with the Kansas Agricultural
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SOIL SURVEY OF KINGMAN COUNTY, KANSAS

By E. W. KNOBEL, United States Department of Agriculture, in Charge, and R. O. LEWIS and C. E. DORNBERGER, Kansas Agricultural Experiment Station

COUNTY SURVEYED

Kingman County is in the south-central part of Kansas in the second tier of counties from the Oklahoma State line (fig. 1). Kingman, the county seat located in the north-central part of the county, is about 50 miles due west of Wichita and 30 miles southwest of Hutchinson. The county is rectangular in shape. Its east and west dimension is 36 miles, and the north and south dimension is 24 miles. The total area is 860 square miles, or 550,400 acres.

Physiographically, Kingman County is part of a nearly flat plain only slightly or moderately dissected. The western half and a large part of the eastern half of the

county were covered with outwash material from the Rocky Mountains, deposited during the Tertiary age, whereas the superficial deposits over a considerable part of the eastern half bordering the larger alluvial valleys are of Permian age.

The slope of the land is toward the southeast. Differences in relief, for the most part, are the result of dissection by South Fork Ninnescah River, which flows in a southeastward course across the northern third of the county, and by Chikaskia River, which parallels South Fork Ninnescah River, in the southern third. The intervening terrain, ranging from 10 to 13 miles in width, is considerably dissected by small creeks which have given rise to many comparatively narrow sharply sloping divides, most of them occurring on the northeastern sides of the rivers within a distance ranging from 2 to 4 miles. The crest consists of a broad, gently sloping divide, locally known as Cleveland Ridge. A second, somewhat narrower, ridge extends southeastward from the northwestern part of the county in the vicinity of Penaloza to a narrow termination just north of Murdock. In the northeastern part, a third but poorly defined ridge flattens out into a rather large area of very gently sloping valleylike land to the south. This area is drained mainly by Smoots Creek.

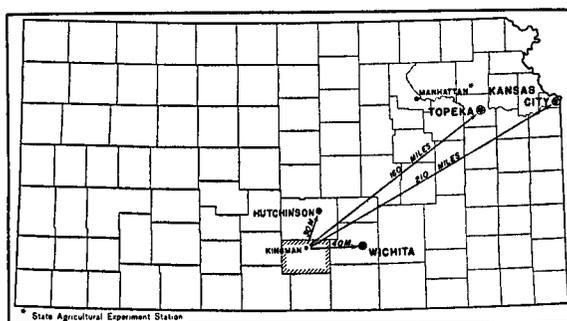


FIGURE 1.—Sketch map showing location of Kingman County, Kans.

The difference in elevation from any point on the crests of the ridges to the nearest river-base level ranges from about 100 to 140 feet, and the width of the sloping terrain covers distances ranging from about $1\frac{1}{2}$ to 6 miles. The shortest slope, with a fall of approximately 100 feet, is along the northern border of South Fork Ninnescah River between Kingman and Murdock and is characterized by a belt of rough broken red clay and shale material of Permian age. A belt ranging from about 3 to 4 miles in width borders the south side of Chikaskia River in the southern part of the county and consists of moderately rolling land, interspersed by numerous drains, having rather choppy irregular slopes. Most of the longer slopes terminate on Cleveland Ridge, which has an elevation of approximately 140 feet above the base level of the two major streams. The range in elevation within the county is about 500 feet. The maximum elevation of 1,840 feet occurs along the border in the west-central part, and the minimum elevation of 1,340 feet is along the eastern border in the central and southeastern parts. Within the city limits of Kingman the elevation ranges from 1,500 to 1,600 feet. Railroad elevations¹ of the principal towns are: Penalosa, 1,724 feet; Kingman, 1,506 feet; Murdock, 1,474 feet; Carvel, 1,631 feet; Belmont, 1,576 feet; Nashville, 1,749 feet; Spivey, 1,497 feet; and Norwich, 1,489 feet.

Surface drainage of most of the county is good. A few square miles along the northern border northeast of Kingman include areas of nearly flat land with poor surface drainage, and some land bordering the river flood plains is subjected to underground seepage and is, therefore, imperfectly drained. Although the two major streams, Chikaskia River and South Fork Ninnescah River, have average gradients of about 7 feet to a mile, the stream channels are shallow, in most places ranging from about 3 to 6 feet below the first bottoms, and the stream beds are almost flat and exceptionally wide. The flow of water is fairly uniform throughout the year; and the water, which is unusually clear and pure, comes mainly from springs in different parts of the county, mainly along the slopes adjoining the larger first bottoms. The smaller creeks are intermittent, and most of them go dry during the latter part of summer. Excellent well water is obtained in all sections. On the higher divides wells range from 50 to 80 feet in depth, but in the lower areas water is obtained at a depth ranging from 10 to 30 feet.

The native vegetation of the virgin uplands consists almost entirely of grasses. According to botanists of the Kansas State College of Agriculture, the more important grasses, in approximately the order of their importance, are big bluestem (*Andropogon furcatus*), little bluestem (*A. scoparius*), buffalo grass (*Buchloë dactyloides*), side-oats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), Indian grass (*Sorghastrum nutans*), sand dropseed (*Sporobolus cryptandrus*), Texas crabgrass, or tumblegrass (*Schedonardus paniculatus*), and switchgrass (*Panicum virgatum*). On overpastured areas, especially ridges, buffalo grass and blue grama (*Bouteloua gracilis*) usually predominate. The more common weeds include ironweed (*Vernonia baldwinii*), vervain (*Verbena stricta*), ragweed (*Am-*

¹ GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1,072 pp. 1906.

brosia psilostachya), wild alfalfa, or tumbleweed (*Psoralea floribunda*), junegrass, or little barley (*Hordeum pusillum*), aster (*Aster multiflorus*), gumweed (*Grindelia squarrosa*), daisy (*Erigeron ramosus*), and mule tail (*E. canadensis* L.). The more common weed pests of cultivated fields include field bindweed (*Convolvulus arvensis* L.), wild licorice (*Glycyrrhiza lepidota*), cocklebur (*Xanthium* sp.), and Russian-thistle (*Salsola pestifer*). Native trees, mainly willow, cottonwood, boxelder, elm, and ash, are scattered along the main drainageways and rivers. Many of the farmsteads have large planted groves of cottonwood trees which serve as windbreaks and for shade. The shade trees in the towns are mainly cottonwood, maple, ash, and elm.

According to the Federal census reports, the population increased from 3,713 in 1880 to 13,386 in 1910, then decreased to 11,644 in 1930. The rural population in 1930 averaged 10.3 persons a square mile. Nearly all the people are native whites, and the census reported only 127 colored people in 1930. The original homesteaders, mainly Germans, migrated from a number of the Middle Western States.

Kingman County was organized from parts of Harper and Reno Counties on February 27, 1874, with less than 20 actual settlers. The first settler in the country now occupied by this county was Martin Updegraff, who located on Chikaskia River about 20 miles southeast of Kingman in 1873.

Transportation facilities, furnished by the Atchison, Topeka & Santa Fe Railway and the Missouri Pacific Railroad, are excellent. These railroads pass through almost all the towns, and few farms are more than 7 miles from the nearest railroad. Wichita and Kansas City are the principal nearby marketing centers, and Omaha, Chicago, Houston, and St. Louis are the more distant markets.

The public highways are in good condition. More than 140 miles of roads are well graded and maintained by the county, and most of the roads along section lines are in good condition. State Highway No. 42 extends east and west across the southern part of the county, and United States Highway No. 54, a concrete road, crosses the northern part.

The first school, which was built in 1874, was attended by four pupils, and as early as 1882 there were 37 organized school districts. There are now nearly 100 public schools and a number of consolidated schools. Churches are numerous and conveniently located. Rural delivery of mail extends to all parts of the county, and telephones, radios, trucks, and automobiles are in common use.

About 30 years ago salt was mined in large quantities in the proximity of Kingman, and huge deposits are known to exist in this locality, but at present the nearest mine is near Hutchinson, Reno County.

CLIMATE

The climate, like that of the greater part of Kansas, is temperate and well suited to general livestock-and-grain farming. It is characterized by rather low yearly precipitation, reasonably mild winters, fairly hot summers, but wide seasonal variations over a period of years. A high percentage of the winter days are bright and clear, but snow flurries are common. In some seasons snow accumulates to

a depth of several inches, and, if northerly winds prevail, drifting is excessive and troublesome in many places. Ordinarily snow remains on the ground only a short time. Occasionally the temperature may fall far below zero for a few days, and such extremes cause more or less winter-killing of fruit trees. The weather during spring and fall is mild, cool, and very pleasant, but during the summer high southerly winds prevail, and occasionally hot burning winds from the southwest may severely injure grain crops. The nights are usually cool.

Approximately two-thirds of the annual precipitation falls during the growing season—May to September, inclusive. Occasional droughty periods in May or June may injure small-grain crops, and if they occur during July or August they may greatly reduce the yield of corn and sorghum. Complete crop failures are unknown, although rainfall is the controlling factor affecting the yields of grain.

The average date of the last killing frost at Norwich is April 13 and of the first is October 23, giving an average frost-free season of 193 days, a sufficient length of time to mature all the crops commonly grown. Sometimes orchard fruits, such as peaches or plums, are greatly injured by late spring frosts. Frost has been recorded as late as May 15 and as early as September 20.

Table 1, compiled from records of the Weather Bureau station at Norwich, gives the normal, monthly, seasonal, and annual temperature and precipitation. These data are fairly representative of climatic conditions throughout the county.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Norwich, Kingman County, Kans.

[Elevation, 1,496 feet]

Month	Temperature, mean	Precipitation		
		Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)
	°F.	Inches	Inches	Inches
December.....	34.1	0.92	0.23	0.22
January.....	32.9	.64	1.02	1.35
February.....	37.0	.99	.85	3.41
Winter.....	34.7	2.55	2.10	4.98
March.....	45.8	1.49	(1)	1.78
April.....	57.0	3.10	1.88	4.88
May.....	65.6	4.30	2.97	7.89
Spring.....	56.1	8.89	4.85	14.55
June.....	75.2	4.36	1.89	8.03
July.....	80.6	2.96	2.03	4.74
August.....	80.3	3.45	4.34	6.19
Summer.....	78.7	10.77	8.26	18.96
September.....	72.5	3.03	1.47	6.44
October.....	59.0	2.47	.55	3.15
November.....	47.1	1.62	.06	.76
Fall.....	59.5	7.12	2.08	10.35
Year.....	57.2	29.33	17.29	48.84

¹ Trace.

AGRICULTURAL HISTORY AND STATISTICS

Prior to the first settlement in the country now included in Kingman County, buffaloes and antelopes roamed the prairies in countless herds. Before the last buffalo was killed in 1877, agricultural development was well under way. Some corn, oats, and wheat were grown, but the cattle which were grazed on the open prairie furnished the chief source of income. Lack of equipment, droughty years, and ravages of grasshoppers and chinch bugs were serious obstacles in producing grain and caused considerable fluctuation in agricultural progress.

Some changes have been made in the kinds of crops grown, as in any other newly settled section, but corn, wheat, oats, and potatoes have always been important. A few crops grown in the earlier days, including buckwheat, tobacco, millet, and castor-beans, were not very profitable and are no longer grown. Hard red winter wheat was introduced shortly after 1875, and its success was at once assured. Leguminous crops, including cowpeas, soybeans, and sweetclover, have been introduced during the last few decades, and sweetclover has gained considerable recognition as a soil builder and pasture crop. Corn was grown extensively before the World War, but the high price of wheat during the war caused a great increase in the wheat acreage, and much of the less desirable tillable land which should have been left in pasture was plowed for this crop.

The types of farming in any locality are determined by the crops that can be produced most advantageously on the soils of the area. In Kingman County the smooth productive soils are utilized very largely in producing cash grain crops. Other crops are grown and fed to livestock in the form of grain, hay, roughage, or silage, and the net income realized is either from the sale of livestock or livestock products. Farmers who own considerable nonarable or strictly grazing land ordinarily practice the raising of livestock in conjunction with cash grain growing. Many farmers, who own good plow land only, practice diversified farming, and their net income is derived largely from the sale of livestock, livestock products, or both.

At present the most successful type of agriculture in this county is diversified farming. The extremely low prices of wheat in 1931 and 1932 forced a number of the wheat growers to reduce their wheat acreage and diversify their crops. Although wheat is the main cash crop, a larger proportion of other field crops than formerly is grown and fed to livestock. Poultry raising and dairying have greatly increased during the last few years, and more and larger home gardens are in evidence. This trend in agriculture is likely to have a balancing effect and reduce the risk involved in staking all on the wheat crop.

The 1935 census reported 1,638 farms in the county, 91 more than in 1930. The average size of farms is 320.2 acres. The size ranges from 3 to 5,000 acres, but the greater number are between 100 and 500 acres. The land in farms represented 94.5 percent of the total area of the county. The 1,547 farms in 1930 included 271 general farms, 950 cash-grain farms, 31 dairy farms, 160 livestock farms, and 22 poultry farms, and the remainder were unclassified.

According to the 1935 Federal census, the total land in farms was 527,447 acres, of which 279,882 acres represented cropland harvested

and 50,484 acres represented plowable pasture. The improved land in farms, including land available for crops and plowable pasture, represented 72.9 percent of the land in farms.

The total amount expended for farm labor in 1929 was \$223,416, or an average of \$216.90 for each of the 1,030 farms reporting such expenditure. Wages in that year ranged from \$25 to \$50 a month with board and lodging.

Only a small quantity of commercial fertilizer is used. Only 24 farms reported the use of fertilizer in 1929, at an expenditure of \$1,989, or \$82.87 a farm reporting.

Owners operated 53.8 percent, tenants 45.9 percent, and managers 0.3 percent of the farms in 1935. Share and cash-rental systems and a combination of the two are practiced. Under the share system, which is most popular, the renter furnishes the equipment, tills the land, seeds the grain, harvests the crop, and delivers a share of the crop to the landlord.

The average farmstead and farm equipment are very good. Most farmsteads have a two-story painted wood residence, a good painted barn, a granary, and a chicken house. On many farms, additional buildings include a silo, a shed for machinery, and other outbuildings. The farm machinery includes gang plows, disks, harrows, grain drills, listers, cultivators, wagons, binders, combines, tractors, and trucks. Many of the farmhouses are supplied with telephones. A few have water piped into the dwellings, and a few have bathrooms. Electricity is used for light and power.

The 1935 census shows that the average value of land and buildings per farm was \$10,705, or \$33.43 an acre. In 1930, 73.4 percent of the value of all farm property represented the value of land, 10.3 percent the value of buildings, 7.5 percent the value of implements, and 8.8 percent the value of domestic animals.

Wheat is the most important cash crop. In 1934, 189,172 acres were devoted to the production of winter wheat.

In this area, the controlling factor in the production of wheat is largely soil moisture, and during years of sufficient rainfall excellent yields are obtained on most soil types. The varieties of wheat most commonly grown are Turkey, Blackhull, and Kanred.

Other small grains, including oats, barley, and rye, are of minor importance. Oats are grown primarily as feed for work animals, to some extent as a nurse crop for sweetclover and alfalfa, and as a step in the rotation between corn and wheat. Kanota, Red Rustproof (Red Texas), and Burt are the principal varieties of oats grown. Kanota has a higher test weight, is slightly earlier, and outyields the last two varieties. Very little barley or rye is grown, and no standard varieties have been developed for this locality.

Weed pests, such as bindweed, are very serious if not checked before they become established. In 1932, 110 farms reported such infested areas. Hot winds sometimes cause serious damage to the wheat crop, and hail and heavy dashing rains when the grain is ripe may prove very disastrous. Occasionally the weather during the fall is so dry that little wheat germinates. Grasshoppers and the hessian fly also cause more or less damage. These hazards, however, are realized only occasionally.

Corn is grown primarily as feed for livestock. Under the prevailing rainfall of only 29.33 inches, corn cannot be depended on to

produce satisfactory yields so consistently as wheat. Prior to 1900 the corn acreage ranged from two to five times as great as the wheat acreage, but since that time the acreage of wheat has exceeded that of corn. The decline in the corn acreage is mainly because of comparatively lower acre yields, owing, in part, to the gradual loss of nitrogen and organic matter through continuous cropping and to the losses, through erosion, of the topsoil on land with sloping relief when devoted to intertilled crops. More modern labor-saving wheat-harvesting machinery has had its influence on the increase of the acreage devoted to wheat and a decrease in that planted to corn. The best adapted varieties of corn grown are Pride of Saline, Freed, Hays Golden, Midland, and Kansas Sunflower.

Grain sorghums are dependable crops to grow in this climatic environment, and they provide an abundance of roughage, silage, or grain. Blackhull, Pink, and Sunrise are recommended varieties of kafir. Feterita and milo are less extensively grown than kafir. Kansas Orange, Sumac, and Atlas are among the best adapted sorgos (sweet sorghums). Sudan grass, a member of the sorghum family, is proving a worth-while crop for pasture, especially among dairymen. Sorghums withstand severe droughty periods much better than corn because the plants become temporarily dormant during dry periods which may be sufficiently severe to greatly curtail the corn yield, but after the droughty period is past the sorghums renew their growth and produce a good crop.

Alfalfa and sweetclover are crops of increasing importance. Although the soils in this county suitable for alfalfa are limited, a wider range of soils can be cropped to sweetclover. These two crops fit well in the rotation for farmers practicing diversification and are especially valuable as soil-improvement crops. Ordinarily three or four cuttings of alfalfa are obtained each season, and the stand is allowed to remain for several years, or as long as it is profitable, whereas sweetclover is utilized mainly as a pasture or soil-improvement crop to be turned under. Alfalfa is followed by small grain, corn, or kafir. Common and Grimm are the main varieties of alfalfa, and both white and yellow blossom sweetclover are grown. Other legumes, such as soybeans and cowpeas, are of minor importance here. Some wild hay is cut from poorly drained first-bottom land and from a few upland areas influenced by seepage. The greater part of the wild hay consists of water-loving grasses and sedges, and it is rather coarse.

The decline in the acreage devoted to orchards, mainly of apples and peaches, is attributable chiefly to irregularity in bearing, killing frosts late in the spring, and to the fact that many orchards were set out on poorly adapted soils. Most of the orchard fruit is grown for home use, but, in good years, some is sold locally. The number of grapevines has also decreased in recent years. Small fruits, including strawberries, raspberries, and blackberries, are grown for home use. The biennial report of the Kansas State Horticultural Society for 1931 lists 452 acres in wild timber, 152 acres in walnut trees, 281 acres in locust trees, 499 acres in cottonwood trees, 439 acres in catalpa trees, and 1,241 acres in various other trees.

In 1930, the Federal census reported the value of all domestic animals at \$2,439,685. Although the raising and fattening of un-

registered hogs and cattle for market is more generally practiced, considerable attention is centered on raising purebred livestock. According to the county agricultural agent, in 1932, there were in this county 165 herds of 12 or more dual-purpose cows, 128 producers of beef cattle, and 137 farmers who used silos. About 80 percent of the cattlemen produced and fattened calves. During the last few years considerable attention has been centered on raising baby beefs for market, especially by the younger members of the farm families, who are enrolled as 4-H club members. This is having a stimulating effect, in that it promotes a more diversified type of farming with less risk involved than when all the farming is staked on a wheat crop. The most important breeds of beef cattle are Hereford, Short-horn, and Polled Durham.

Although raising of hogs is much less important than raising of cattle, most farmers raise enough hogs for home needs, and many raise from 20 to 60 or more head for market. Most of the hogs for market are raised in connection with the feeding of beef cattle, although most dairymen and the farmers who practice diversification of crops raise some hogs. Most of the hogs are either purebred Duroc-Jersey, Poland China, Hampshire, and Chester White, or a first cross of these breeds.

Dairying is receiving considerable attention. Although Jersey and Holstein-Friesian are the most common breeds of dairy cattle, a large percentage of the total number of cows milked are either dual-purpose cows, of mixed dairy breeds, or grades.

A few sheep are raised, and some are shipped into the county to be fattened on corn and alfalfa.

Horse raising is confined to the breeding of work mares. The Percheron is the most common breed, but, owing to the increasing use of tractors, trucks, and combines, horse raising as a business is not profitable. Some mules are raised.

The raising of poultry is a general but minor farm activity. The combination of dry climate, mild winters, and abundance of grain causes poultry raising to appeal to most farm families. Ordinarily from 50 to 100 chickens are kept, and many farmers maintain flocks of several hundred. The breeds are chiefly Leghorn, Plymouth Rock, Rhode Island Red, and Buff Orpington. Poultry products are either sold or exchanged for farm or household supplies in the local towns. Some turkeys, ducks, and geese are raised.

SOILS AND CROPS

Kingman County lies within the Great Plains region of Kansas, in a belt characterized by comparatively low rainfall and dark soils. The soils have been developed under a grass cover. No excessive leaching of soluble material from the soil has taken place, hence the fertility is still considerably higher than in many parts of eastern Kansas and Oklahoma, which have a much higher annual rainfall. The moisture supply, therefore, is most commonly the limiting factor in the yields of the various crops best suited to the soils under the prevailing climatic conditions. Inasmuch as the climatic environment is practically the same over areas as small as the average-sized county, soil differences are not due to unequal climatic factors but to

the origin and differences of the soil-forming materials and their unequal distribution and to the wide differences in topographic features, even over short linear distances.

The agricultural soils may be broadly grouped, according to topographic position, as soils of the uplands and soils of the river bottoms. On the basis of important characteristics, they may be divided into light-colored and dark soils. The light-colored soils, for the most part, occur on both sides of the main stream valleys, occupying rather wide but irregular sloping belts leading onto the broad smooth upland divides of mild relief. The surface soil is thinner and less dark on these sloping lands because of the greater run-off of water, thus leaving less moisture to penetrate into the soil for the growth of grasses, the remains of which are responsible for the content of organic matter and the color of the soil. On the sloping land, soil erosion is also somewhat greater, especially when the soil is cultivated. A few areas, however, in the southwestern and southeastern parts of the county, have fairly gentle relief and very few drainage-ways, but the excessively sandy character of the soils has not favored a thick growth of grasses, hence very little organic matter has accumulated and the soils have remained light in color. Other soils having very gentle relief are either light or intermediate in color, mainly because a very compacted pebbly subsoil has produced a droughty condition and prevented a heavy growth of grasses. The greater proportion of the soils of the first bottoms are light colored, because the sediments laid down in the past by overflows have been excessively sandy and, therefore, unfavorable to a dense growth of grasses and the consequent accumulation of organic matter.

The light-colored soils cover approximately two-thirds of the total area. Crop yields are lower and more uncertain on these soils than on the dark soils. The smooth relief of the dark soils has allowed cultivation of the entire area except, possibly, 5 percent which is still utilized as pasture. Many of these soils are developed on broad continuous upland divides with mild relief, such as Cleveland Ridge. The general prosperity and future welfare of the inhabitants depend largely on the use and conservation of these soils, because they not only are more fertile but are easier to cultivate and lie more favorably for the use of modern power machinery. They have developed under the influence of a grass vegetation, the continuous decay of which, mainly the grass roots, has favored the accumulation of large quantities of organic matter.

The high content of organic matter is a very desirable asset in the production of crops. It increases the water-holding capacity, makes the soil more absorptive and retentive of moisture, helps to maintain a desirable tilth, and greatly retards harmful erosion. It is also the chief source of nitrogen which is one of the important plant nutrients for growing crops.

In addition to their dark color, many of the soils, especially the finer textured soils, are characterized by an abundance of lime at slight depths. The high content of organic matter and lime has helped to prevent the formation of a claypan layer, and even the heavier surface soils are loose, granular, and crumblike and are not very difficult to till.

All the crops commonly grown in the county are produced to greater or less extent on both the light- and dark-colored soils, and probably nearly 90 percent of the arable land is under cultivation. In order of their importance, the chief crops are wheat, corn, sorghum, oats, alfalfa, and barley. Of the land in crops, wheat occupies about 69 percent, corn 13 percent, sorghums 9 percent, oats 5 percent, alfalfa 1.7 percent, barley 0.6 percent, and miscellaneous crops 1.7 percent. Wheat is most consistently grown on the smooth areas of both dark- and light-colored soils having from medium- to heavy-textured surface soils and fairly heavy subsoils, and corn is grown on dark loams and sandy loams with friable subsoils, which occur in lower positions where a higher moisture content is available in the subsoil and substratum. Alfalfa does best on soils which occupy smooth low-lying slopes and which have a good supply of organic matter in the topsoil and a generally friable subsoil containing lime in the lower part. The higher returns derived from one crop than from another are not necessarily the result of unusually favorable soil conditions for that particular crop but may be because of the greater ability of one crop than another to adapt itself to the conditions under which it must grow.

Inasmuch as the soils of this county differ greatly in their productive capacity and crop adaptabilities, they may be arranged in groups, each of which includes soils that are fairly uniform in their capabilities for use, in many respects have similar soil characteristics, and are used for some particular crop or crops more extensively than soils of some other group. The upland soils include three subgroups based on soil characteristics and other features which affect their use, namely: (1) Dark soils with heavy subsoils, (2) dark soils with friable subsoils, and (3) light-colored soils with friable subsoils. The soils of the stream bottoms form a less extensive group.

In the following pages the individual soils of the different groups are described, and their crop adaptations are noted; the soil map accompanying this report shows their distribution; and table 2 gives their acreage and proportionate extent.

TABLE 2.—Acreage and proportionate extent of the soils mapped in Kingman County, Kans.

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Albion loam.....	55, 104	10.0	Pratt loamy sand.....	19, 804	3.6
Albion loam, heavy-subsoil phase.....	63, 808	11.6	Pratt loamy sand, rolling phase....	1, 344	.2
Albion loam, dark-colored phase.....	11, 392	2.1	Pratt loamy sand, gray phase.....	6, 016	1.1
Albion loam, shallow phase.....	2, 496	.4	Grant loamy sand.....	5, 312	1.0
Albion loam, alkali phase.....	2, 432	.4	Grant loamy sand, shallow phase....	3, 136	.6
Albion sandy loam.....	130, 560	23.7	Grant loamy sand, imperfectly drained phase.....	1, 920	.3
Albion sandy loam, shallow phase....	1, 024	.2	Pratt sand.....	4, 544	.8
Albion silt loam.....	10, 752	2.0	Arkansas loamy sand.....	14, 080	2.6
Albion clay loam.....	99, 136	18.0	Arkansas sandy loam.....	14, 784	2.7
Albion clay loam, shallow phase....	3, 968	.7	Arkansas clay loam, poorly drained phase.....	1, 984	.4
Idana silty clay loam.....	4, 288	.8	Yahola sandy loam.....	960	.2
Clark silty clay.....	960	.2	Albion sandy loam, broken phase....	11, 328	2.0
Clark clay loam.....	9, 088	1.6	Vernon clay, broken phase.....	5, 248	.9
Clark clay loam, shallow phase....	896	.2	Rough broken land (Vernon soil material).....	13, 248	2.4
Grant loam.....	10, 752	2.0	Pratt sand, dune phase.....	832	.2
Renfrow clay.....	10, 944	2.0			
Renfrow silt loam.....	6, 336	1.1			
Canadian sandy loam.....	4, 224	.8			
Canadian silty clay loam.....	1, 536	.3			
Vernon very fine sandy loam.....	16, 064	2.9			
			Total.....	580, 400	-----

DARK SOILS WITH HEAVY SUBSOILS

The dark soils with heavy subsoils occupy the broad gently undulating upland divides having very mild relief. This is the most extensive group in the county, and the soils rank among the most important agriculturally. More than 95 percent of their area is cultivated. This group includes the Albion, Clark, and Renfrow soils, Grant loam, and Idana silty clay loam. The total area covered by them is 602 square miles, or 70 percent of the area of the county.

These soils are utilized mainly for the production of wheat. Their smooth relief allows easy manipulation of modern power machinery. The wheat crop ordinarily matures before prolonged droughty periods occur, and these soils have a higher moisture-holding capacity than many of the light-colored soils. The heavy subsoil has little effect on the root development of wheat. Corn, however, is greatly affected if droughty periods prevail, and the yields are more seriously curtailed than those on the dark soils with friable subsoils.

The proportionate acreages devoted to the different crops on the soils of this group differ somewhat from those given for the cultivated land of the county as a whole. Wheat is grown on approximately 75 percent of the cultivated area, corn on about 10 percent, sorghums on 8 percent, oats on 5 percent, alfalfa on 1 percent, barley on 0.5 percent, and miscellaneous crops on 0.5 percent.

Albion loam.—Albion loam is an extensive and agriculturally important soil. The more extensive areas are south and southeast of Cleveland and southeast of Nashville. This soil differs from Albion loam, heavy-subsoil phase, mainly in that the subsoil is generally more friable and the topmost layer does not have such a uniformly dark brown color, although in places these two soils are closely associated, and the boundary between them is rather arbitrary.

The topsoil of Albion loam is brown or moderately dark brown rather light loam or sandy loam. This layer, at a depth of 10 or 12 inches, grades into brown or rusty-brown heavy loam or clay loam. The subsoil, at a depth of 14 or 16 inches, is rusty-brown clay loam or friable sandy clay with a slight red tint. At a depth ranging from about 24 to 30 inches it is underlain by brown, light-brown, or rusty-brown friable sandy clay containing a small proportion of small pebbles or gravel, but these are less abundant than in the material underlying Albion clay loam and Albion sandy loam.

This soil occurs in smooth undulating areas, ordinarily on lower slopes. Some of the topsoil has been removed by erosion but, in general, enough remains to give a topsoil of good physical condition. In a few areas lying within 3 miles of the Chikaskia River Valley, mainly on the south side, the topsoil is darker than typical, but the subsoil is less heavy than the corresponding layer of Albion loam, heavy-subsoil phase. These areas have a rather pronounced slope, in fact, a body 3 miles south of Zenda is rolling, yet the topsoil is darker than most of the smoother areas. Several areas northwest of Murdock and northeast of Kingman have fairly dark surface soils, almost as dark as the surface soil of the heavy-subsoil phase, but the subsoil is not so heavy as that of the phase. On several slopes near drains, where the Permian "Red Beds" formation lies at a

slight depth, the topsoil has a reddish-brown cast, but such areas were too small to indicate separately on the soil map. The soil in the areas with slightly darker surface layers is not of great agricultural importance, although the productivity of these areas is equal to, if not slightly higher than, that of the larger typical areas in the western part of the county. Several bodies bordering areas of Albion silt loam have a lighter colored topsoil than typical and a higher content of very fine sand which gives rise to a finer textured loam topsoil. The subsoil contains less sandy material and a comparatively higher percentage of silt, which makes the material rather friable, also a noticeable content of lime in the form of concretions ranging from one-fourth to about 1 inch in diameter. Such areas were too inextensive and not sufficiently different to map separately.

As a whole, this is the most productive soil of this group. Approximately 90 or 95 percent of the land is cultivated, and the unbroken areas support an excellent growth of grasses. Most of these marginal areas have rather rolling or decidedly sharp slopes. Wheat, kafir, corn, sorghums, and alfalfa are the chief crops, and yields average slightly larger than those on Albion clay loam and Albion sandy loam.

Albion loam, heavy-subsoil phase.—Albion loam, heavy-subsoil phase, occurs on the broad nearly level or gently sloping upland divides. The more extensive areas lie east and west of Cleveland, east and west of Penalosa, and northeast and southeast of Norwich.

The topmost layer, which is 6 or 8 inches thick, consists of dark-brown loam or heavy loam. Below this is light-textured clay loam which grades into brown clay loam at a depth of 8 or 10 inches. When wet the surface soil has a slightly sticky feel, indicating a higher content of clay than ordinarily occurs in a loam. At an average depth of about 14 inches the soil material is heavy clay loam which is very hard and compact when dry. It grades into rusty-brown or slightly reddish brown clay loam. Below a depth ranging from 30 to 36 inches the soil material is slightly lighter colored and contains a comparatively higher percentage of coarse sand and pebbly material. Few pebbles occur in the topsoil. The dark color of the surface soil indicates the presence of organic matter which has strong absorbing power for both moisture and heat. This material retains moisture well and is the chief source of nitrogen, an essential plant nutrient.

This is one of the most desirable and productive soils in the county. Its gently undulating relief and good drainage throughout allow cultivation of practically all the land. Probably 95 percent or more is cultivated. Ordinarily the soil does not drift, and it is not difficult to cultivate. The fact that it occurs on broad smooth areas allows the operation of the most improved labor-saving machinery, particularly that used in the production of wheat. Wheat yields (pl. 1, A), although sometimes rather low, are much less variable than those of corn. The crop matures mainly on moisture obtained from spring and early summer rains and is not subjected to the frequent midsummer droughts that so effectively reduce yields of corn. A corn crop may be in excellent condition until the tasseling stage, and then a prolonged drought may very greatly curtail the yield. Sorgo, kafir, or other sorghums survive under wide variations in moisture supply and

are more dependable crops than corn over an extended period of years. Wheat yields range from about 8 to 25 bushels an acre, corn 10 to 30 bushels, kafir 20 to 40 bushels, oats 12 to 30 bushels, and alfalfa one-fourth to three-fourths ton at each of three or four cuttings. Alfalfa, however, is not well suited to this soil because of insufficient underground water and a rather tight subsoil which retards root penetration. It does fairly well when rain is plentiful, but in dry seasons it returns very light yields.

Orchard crops are not especially well suited to this soil, but enough fruit for home use can be grown. Vegetables and small fruits generally succeed. Moisture is the controlling factor for these crops, as it is for small grains and corn.

Albion loam, dark-colored phase.—Albion loam, dark-colored phase, is a very desirable and productive soil but is not very extensive in this county. The larger bodies occur in the eastern and south-eastern parts.

This soil differs from Albion loam in having a much darker and thicker surface layer, and it seems to have a much higher capacity for retaining moisture. This is due in part to the fact that its occurrence is restricted to lower slopes or low-lying positions, where, in addition to the local rainfall, it receives considerable run-off and underground seepage water. Moreover the prevailing ground-water level is higher than in most soils, and in places the Permian "Red Beds" material occurs at as slight a depth as 5 feet below the surface. This material greatly restricts the downward movement of water, but the land is very gently sloping and well drained, and underdrainage is excellent. Therefore a rank growth of vegetation has prevailed, even in a belt characterized by low rainfall. An abundance of organic matter has accumulated, which has imparted the dark color to the soil material to a depth ranging from 18 to 24 or more inches.

The topsoil consists of very dark brown or very dark grayish-brown loam or sandy loam. Below a depth ranging from 15 to 20 inches the material is brown or slightly rusty brown very loose friable sandy clay which is exceptionally permeable to moisture and roots. Below a depth of 3 feet the sandy clay material is splotched more or less with pale grayish-yellow and grayish-brown sandy clay soil material which continues downward to an undetermined depth.

Nearly all this land is cultivated. In earlier years corn was the principal crop and still is grown to a considerable extent. Good yields are produced, as the soil characteristics are highly favorable for the production of corn under the prevailing climatic conditions. This is also a good soil for wheat and is suitable for growing potatoes, various garden vegetables, and small fruits. Acre yields of corn range from 20 to 50 bushels, wheat 12 to 30 bushels, and alfalfa one-half to 1 ton from each of the usual three or four cuttings. Grain sorghums produce high yields which furnish an abundance of roughage.

This soil is exceptionally desirable for orchard fruits because of the very permeable subsoil and available moisture in the porous subsoil and substratum. Most owners of such land have a grove of very large cottonwood trees, which serves as a windbreak and protects the orchards.

Albion loam, shallow phase.—The shallow phase of Albion loam occurs mainly in the southeastern part of the county. The topsoil consists of brown loam similar to that of typical Albion loam. It is underlain, at a depth ranging from 10 to 14 inches, by light-brown or rusty-brown clay loam containing very little or no pebbly or gravelly material. This layer is underlain, at a depth ranging from 12 to 24 inches, by dull-red clay. In plowed fields the red clay is exposed in places, imparting a red cast to the surface soil. In a few areas in the south-central part of the county, from 1 to 3 miles north of Rago, similar soil material overlies a subsoil resembling that of Vernon loam, which is brighter red and has a very noticeable content of very fine sand particles. A few of the exposed spots in this part of the county are reddish brown, and others are light brown and hard, indicating an accumulation of alkali, or sodium salts, exposed at the surface. These bodies of shallow soil are not so desirable as those in the southeastern part of the county, but all the areas are about equal in agricultural value to typical Albion loam. Corn, wheat, and alfalfa are the best adapted crops, and yields average about the same as those obtained on Albion loam.

Albion loam, alkali phase.—Albion loam, alkali phase, is a soil of small extent, most of which is in the northeastern part of the county. It occurs in low-lying gently sloping or nearly flat areas, on which has accumulated an excess of salts. Practically all the land could be cultivated, but probably not more than 60 or 70 percent of it is used for cultivated crops. Surface drainage is imperfect, because of the presence of many hard, barren alkali spots, most of which lie 6 or 8 inches lower than the intervening Albion loam. These spots range in size from 10 to 20 feet in diameter and are from 20 to 50 yards apart. Ordinarily the 6- or 8-inch topmost layer consists of heavy loam grading toward clay loam. This layer grades into very heavy massive or blocky clay containing a noticeable quantity of sand grains and pebbly material. The alkali spots closely approach claypan, but the material is not a true claypan but more nearly a semiclaypan. The subsoil at a depth of 8 or 10 inches is rusty-brown or brown clay which grades into less heavy grayish-brown clay containing some lime concretions and gravel.

This soil is cropped mainly to wheat, oats, or kafir. Sweetclover would prove beneficial in loosening the surface soil and subsoil and thereby improve the underdrainage which is imperfect. This soil is rated as less valuable than the other soils in this group, and it is more nearly equal to those in the group of light-colored soils with friable subsoils.

Albion sandy loam.—Albion sandy loam is the most extensive soil in Kingman County, covering 204 square miles. It occurs in most sections. The largest areas are west of Kingman.

The 9- to 14-inch topsoil material grades from medium-brown sandy loam into lighter brown friable sandy clay. The subsoil, at a depth ranging from 16 to 22 inches, is rusty-brown or slightly reddish brown sandy clay grading, at a depth ranging from about 30 to 36 inches, into lighter shades of brown friable sandy clay. In most places small pebbles or gravel are intermixed through the surface soil and subsoil, and where gravel are sparse, the soil material

contains a higher percentage of coarse sand. In plowed fields the color of the surface soil is some shade of brown, but the texture is more or less variable, owing to considerable shifting of the plow soil by wind action. In areas closely associated with Albion loam, the subsoil is heavier but not so heavy as the subsoil of typical Albion loam. Areas in proximity to Pratt loamy sand, gray phase, have a dark grayish-brown topsoil, and the subsoil is light brown or light rusty brown.

Approximately 80 percent of the total area of this soil is cultivated, and the rest is utilized for pasture (pl. 1, *B*). The pasture land is confined to the more pronounced slopes near drains, and the more nearly level areas, which are the most productive, are used for cultivated crops. The chief crops grown are wheat, corn, kafir, Sudan grass, oats, and some sweetclover and alfalfa. Wheat is grown extensively on this soil, and a fairly large acreage is devoted to corn. Soil blowing often seriously injures a wheat crop, especially during the winter and early spring. As corn is usually listed, danger from soil blowing is ordinarily eliminated. Very little alfalfa is grown as this is not a sure crop unless moisture conditions are very favorable when the crop is seeded and when the plants are young. Sufficient lime is not always available for the proper growth of alfalfa. The soil needs considerable organic matter supplied in the form of green-manure crops, such as sweetclover, or through applications of barnyard manure. Crop yields differ greatly, depending on the season, but moisture is the limiting factor in crop production. Corn yields range from about 10 to 30 bushels an acre, kafir 20 to 40 bushels, wheat 5 to 20 bushels, and alfalfa about one-half ton from each of three or four cuttings.

Albion sandy loam, shallow phase.—Albion sandy loam, shallow phase, is of little agricultural importance. Most of it occurs in the western part of the county.

The surface soil consists of a thin uneven covering of dark sandy loam, in which large accumulations of lime in places have imparted a gray or light-gray color even to the topmost material. This layer is underlain by highly calcareous and very light colored friable soil material.

Most areas of this shallow soil occupy rather sharp knoll-like positions, from which the rainfall runs off and the soil has not been leached so deeply as in level areas. In addition the soil has undergone both wind and water erosion, thereby leaving more of the highly concentrated limy material near the surface or exposed.

Soil of this phase is not so productive as the typical soil, owing to scarcity of moisture, low organic-matter content, and greater susceptibility to wind action. The texture of the surface soil in each area varies in accordance with the soil bordering it, especially near the boundary where it gradually changes to the texture of the associated soil.

Albion silt loam.—Albion silt loam is a very desirable soil, but it is not extensively developed. The largest body is east and southeast of Cunningham, and most of the other areas are in the southwestern part of the county. This soil closely resembles Albion loam, from which it differs mainly in that the surface soil is of much finer texture and contains a rather high percentage of very fine sand

grains. In places the texture closely approaches very fine sandy loam. Some of the areas would possibly analyze a loam. The content of clay is sufficiently high that the texture closely approaches silty clay loam. In different places, the mapped areas approach silty clay loam, fine-textured loam, and very fine sandy loam, but the dominant texture is silt loam.

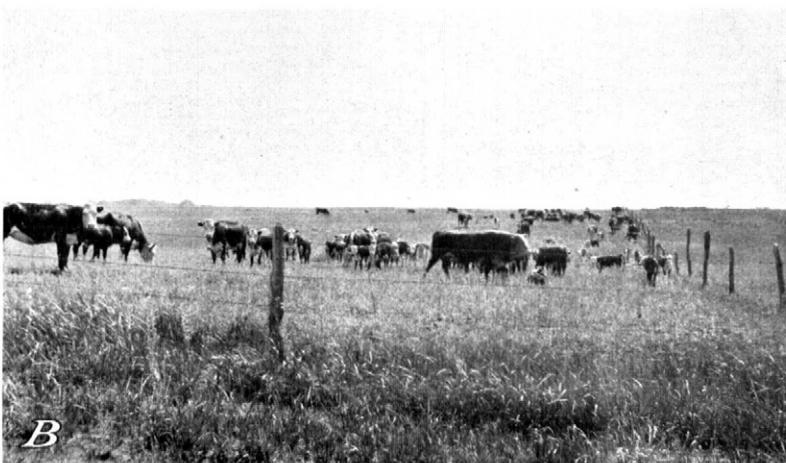
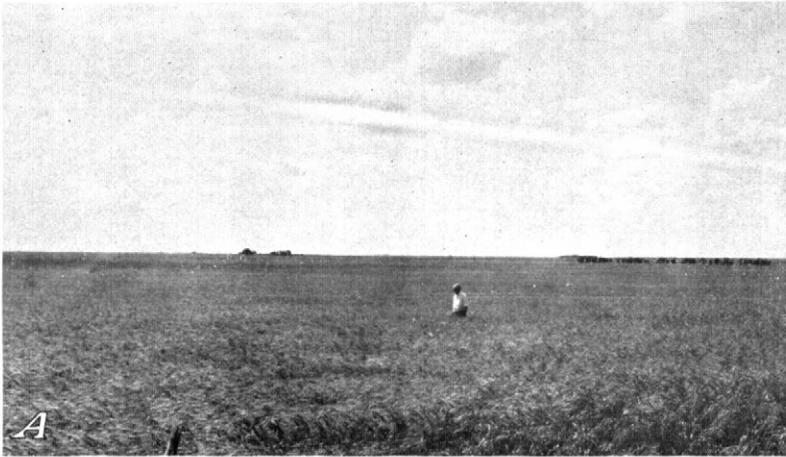
The topsoil is dark-brown silt loam ordinarily grading, at a depth of 14 or 16 inches, into brown silty clay loam which gradually merges with slightly heavier lighter brown or rust-brown soil material. At a depth of about 24 inches the texture grades from silty clay to clay, and the soil material contains a noticeable sprinkling of sand grains and small pebbles which occur rather sparingly to a depth of several feet. A few lime concretions are intermixed with the soil below a depth ranging from 26 to 30 inches. In cuts along roads the subsoil material has a slightly reddish brown cast like that underlying the other Albion soils.

As this soil is absorptive and retentive of moisture, practically all of it is cultivated. Wheat, corn, and alfalfa are the chief crops grown, and the yields ordinarily average higher than those obtained on Albion loam. Most of the areas occupy comparatively low levels and are smooth or very gently undulating, with good surface drainage and underdrainage. The subsoil is not so heavy as to seriously retard root development of deep-rooted crops, and therefore orchard fruits, small fruits, and vegetables are well suited to this soil.

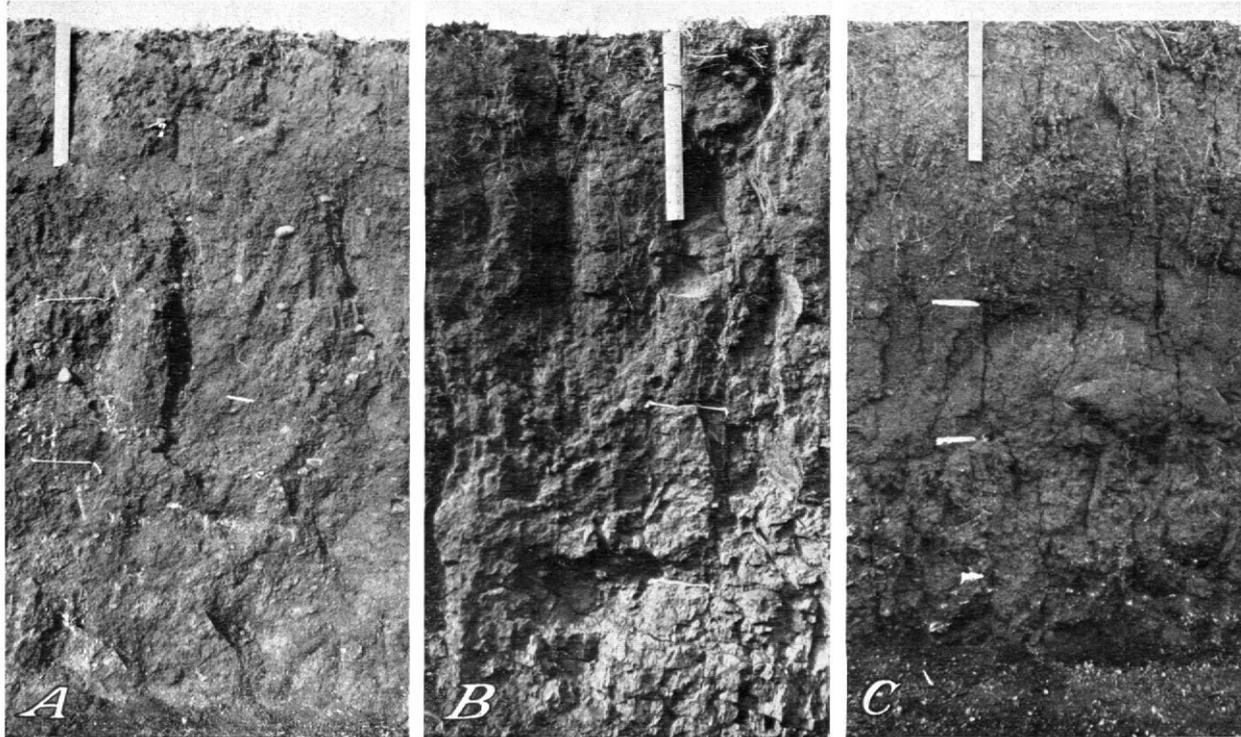
Albion clay loam.—Albion clay loam is one of the more extensive soils. It occupies a total area of 154.9 square miles. The larger bodies lie north and northwest of Norwich, extending almost to Cleveland in the central part of the county, a few rather large areas are in the northeastern part, and less extensive areas are well distributed over the county.

This soil is more or less variable in different parts of the county. In most places the topsoil of the virgin soil is brown or dark brown, but where cultivated it is brown, rust brown, or medium brown, and ranges in texture from heavy loam to clay loam. At a depth ranging from 10 to 15 inches the soil material is very compact in place, especially when dry, rusty brown in color, and clay loam or heavy sandy clay in texture. Below a depth ranging from 36 to 40 inches the material grades from heavy clay loam into lighter brown rather coarse sandy clay. Small pebbles and coarse sand grains occur in various quantities throughout the surface soil, subsoil, and substratum (pl. 2, A), and in plowed fields, especially after rains, pebbles, mainly quartz and granite, are very conspicuous. The prevalence of gravel has tended to make this soil less absorptive and retentive of moisture, consequently crops on it suffer more quickly during droughts. Normal root development is so retarded that fruit trees are stunted and never attain the vigor and productive capacity as do those on soils having friable and permeable subsoils. Comparatively few planted cottonwood trees survive on this soil, and those surviving are noticeably stunted.

Although all this land is plowable, probably not more than 70 or 75 percent is under cultivation. The unbroken areas comprise some of the most uniform and best grazing land in the county. Wheat and kafir are among the more dependable crops grown. Very little



A, An excellent stand of wheat on Albion loam, heavy-subsoil phase; *B*, cattle grazing on Albion sandy loam.



A, Profile of Albion clay loam, showing an admixture of gravel in the sandy clay subsoil; *B*, profile of Idana silty clay loam; *C*, profile of Renfrow silt loam, showing white carbonate of lime concretions beginning at a depth of about 3 feet.

alfalfa is grown, and corn is not a dependable crop, because of the unfavorable soil characteristics. If sufficient moisture is available at the right time, a good yield of wheat is obtained, but average yields are consistently lower than those obtained on other loam or clay loam soils. Kafir is possibly one of the surest and most dependable crops suited to the soil and climate. In most years, enough vegetables and small fruits can be grown to supply home needs.

Albion clay loam, shallow phase.—The larger areas of Albion clay loam, shallow phase, are in the southeastern part of the county.

Soil of this phase consists of brown or rather dark brown clay loam containing a noticeable quantity of small pebbles or gravel, to a depth ranging from 10 to 14 inches, where it is underlain by rusty-brown heavier clay loam like that underlying the topsoil of typical Albion clay loam. This layer, in turn, is underlain by the typical dull-red or red clay which in most places begins at a depth ranging from 15 to 30 inches. In plowed fields, some spots of the exposed red clay impart a decidedly red cast to the soil material. These spots or narrow strips occur near drains and indicate a very shallow remnant of the overlying Albion clay loam.

This soil is not quite so productive as Renfrow clay but is more productive than typical Albion clay loam. The relief ranges from smooth to gently sloping, and both surface drainage and underdrainage are good. Practically all the land is cultivated, mainly to wheat, corn, and alfalfa.

Idana silty clay loam.—Idana silty clay loam, although not extensive, is one of the best developed and most uniform soils in the county. It is productive and very desirable. Most of it occurs in a single body about 6 miles south of Cunningham.

The topsoil consists of dark grayish-brown silty clay loam grading at a depth of about 6 inches into slightly acid brown heavy silty clay loam or silty clay. At a depth ranging from about 14 to 20 inches the soil material is more dense. This is the layer of maximum density and is a true claypan. The soil material is slightly lighter in color than that in the layer above and in places has a red tinge. Some gravel are embedded in this material which, where undisturbed, is very tough. This layer is underlain, at a depth of about 24 inches, by grayish-drab or olive-brown clay containing a few lime concretions in the lower part. The material below a depth ranging from 28 to 36 inches is more friable and is brown or light reddish brown, but no concentrated or heavy accumulations of lime occur as in the corresponding lower subsoil layer of the Clark soils. In many places loose sandy and gravelly loam occurs below a depth of 36 inches (pl. 2, B).

This soil occupies broad smooth gently undulating divides similar to those occupied by Albion loam, and it has good surface drainage. The subsoil, although heavy, does not restrict underdrainage to such an extent as to interfere with normal plant development.

Nearly all the land is under cultivation. Wheat is the dominant crop, but corn, kafir, and other crops are grown to some extent. Yields of wheat and corn are possibly a little higher in average years than those produced on Albion loam and about equal to those obtained on Albion silt loam, Clark silty clay, and Clark clay loam.

Clark silty clay.—The main body of Clark silty clay occurs along the western boundary of the county about 6 miles south of Cunningham. The topsoil consists of dark-brown or dark grayish-brown silty clay or clay, locally referred to as "gumbo." At a depth of 12 or 15 inches the topsoil is underlain by white pebbly chalky material intermixed with the clay and at a depth ranging from 18 to 24 inches by white chalky calcareous material occurring in both small and fairly large pockets surrounded by olive-gray clay. Ordinarily, at a depth ranging from 40 to 50 inches, the limy material is less abundant, but the depth at which it occurs, its mode of occurrence, and its comparative abundance are variable.

Practically all the land is cultivated. Wheat, corn, and alfalfa are the chief crops grown, and yields are about the same as those obtained on Idana silty clay loam. This soil is difficult to handle if it is not worked under optimum moisture conditions. The land is very smooth or gently undulating and is therefore suitable to the use of modern machinery. Surface drainage is sufficient to carry off all surplus surface water. This is a productive soil but, owing to its heavy character, is not well suited to such crops as melons, vegetables, and fruits. Sweetclover, alfalfa, and cowpeas greatly improve the tilth, as well as the fertility of this soil.

Clark clay loam.—Clark clay loam occurs in several areas in the western part of the county, the largest single body lying 2 miles south of Cunningham. This soil differs from Clark silty clay mainly in that the surface soil and the entire soil mass contain a very noticeable percentage of sand grains, sufficient to make the texture average a clay loam. The subsoil contains the characteristic white chalky material in various degrees of abundance, and in plowed fields, where the surface soil is thin, a light-gray color is noticeable in large spots ranging from 1 to 4 rods in width.

Practically all the land is cultivated, and under average conditions it is a little easier to handle than Clark silty clay. Drainage is good, owing to the smooth, gently undulating relief. Like Clark silty clay, this is a productive soil and is cropped chiefly to wheat, corn, kafir, and alfalfa. Acre yields of corn range from 15 to 20 bushels, wheat 12 to 35 bushels, and alfalfa about one-half to three-fourths ton a cutting with the usual three or four cuttings a season.

Clark clay loam, shallow phase.—The shallow phase of Clark clay loam occurs in one continuous body about 1½ miles northeast of Nashville in the southwestern part of the county. It is closely associated with Clark clay loam.

This soil differs from typical Clark clay loam in that the surface layer is much thinner, more variable, and lighter in color and texture. The land is not so smooth or well suited to long-continued cultivation. The topsoil is extremely variable, ranging from a 6- to 10-inch layer of dark clay loam material on the high smooth areas to a thin irregular covering on the slopes. In many places, especially where the land is cultivated, light-gray silty clay loam material, averaging lighter in texture than the underlying soil material of other members of the Clark series, is exposed on the surface.

This soil occurs as a border on the outer edge of smooth areas of Clark clay loam, and it is dissected and sharply sloping. The land is very susceptible to erosion and must be carefully managed. Less than one-half of it is cultivated. Wheat is the principal crop, but yields are not so high as those produced on typical Clark clay loam or Clark silty clay. The uncultivated areas can best be utilized for grazing.

Grant loam.—Grant loam is closely associated with Vernon very fine sandy loam. The larger areas are in the south-central and southeastern parts of the county. This soil occurs in the lower and smoother situations and has a slightly darker or a more dull reddish-brown surface soil than Vernon very fine sandy loam. It also has a thicker surface layer as well as a thicker subsoil layer overlying the parent shales. Erosion has only slightly injured this soil. It is not nearly so erosive as Vernon very fine sandy loam because of its smoother relief and higher content of organic matter.

The topsoil consists of dark reddish-brown or dull-red fine-textured loam which grades toward very fine sandy loam. It is underlain, at a depth ranging from 10 to 15 inches, by dull reddish-brown heavy loam or silty clay loam, and this, in turn, at a depth ranging from 18 to 24 inches, by reddish-brown or red clay loam. The underlying shale is reached at a depth ranging from about 4 to 6 feet.

Grant loam is an excellent and productive soil, and nearly all of it is cultivated. Corn, wheat, kafir, and alfalfa are the most important crops, and the yields are about the same as those produced on Renfrow clay and Renfrow silt loam. Because of the rather high proportion of very fine sand particles in the surface soil, the land warms early and is very easy to cultivate. It is one of the best corn soils in the county. Early vegetables, potatoes, melons, small fruits, and orchard crops are well suited to this soil.

Renfrow clay.—Nearly all of Renfrow clay occurs in one large area in the vicinity of Murdock. This is an excellent soil and is fairly important agriculturally.

This soil differs from Vernon very fine sandy loam mainly in that the relief is more gently undulating, the topsoil is darker and heavier in texture, and the underlying parent shale occurs at a greater depth below the surface. The topsoil consists of dark reddish-brown silty clay or clay about 10 or 12 inches thick. It is underlain by clayey material which is not quite so dark and this, in turn, at a depth ranging from 22 to 26 inches, by dull-red clay containing a few lime concretions. Below a depth of 36 inches the material is brick-red or brownish-red clay, commonly called "keel", which grades into very compact material which becomes dense and hard when dry.

All this soil is cultivable, and about 98 percent is under cultivation. The land is smooth and gently undulating and is suitable for the use of modern machinery. Surface drainage is excellent. The heavy texture of the clay causes some difficulty in tillage operations, especially when the clay is very dry, and if the ground is worked when too wet puddling or baking may result.

Wheat is by far the most important crop grown, and probably about 90 percent of the total acreage is planted to that crop. Some corn, sorghum, and alfalfa are grown. Alfalfa succeeds best on the lower slopes or nearly flat areas where the soil contains the most

moisture. Corn yields range from about 15 to 40 bushels, wheat 12 to 25 bushels, and alfalfa one-half to three-fourths ton a cutting, with the usual three or four cuttings a season.

Renfrow silt loam.—Renfrow silt loam is not extensively developed. Nearly all of it occurs in a single area in the northeastern part of the county northwest of Murdock.

The difference between this soil and Renfrow clay is that it occurs in lower and smoother areas, is slightly darker, considerably lighter in texture, and ordinarily more productive. The very dark reddish-brown silty clay loam topsoil grades at a depth ranging from 10 to 15 inches into dull reddish-brown silty clay, and this, at a depth ranging from 20 to 26 inches, into dull-red clay which continues to a greater depth before shale or keel is reached than does the corresponding layer underlying Renfrow clay. Lime concretions are common below a depth ranging from 26 to 30 inches (pl. 2, *C*).

This is a highly productive soil, and all the land can be cultivated, although from 5 to 8 percent is still in virgin pasture. Wheat, corn, alfalfa, Sudan grass, and kafir are the most common crops grown. Wheat yields range from about 15 to 35 bushels an acre, corn 20 to 45 bushels, oats 15 to 45 bushels, grain sorghum 20 to 50 bushels, and alfalfa about one-third to 1 ton from each of the usual three or four cuttings. This is probably the best soil in the county for the production of alfalfa. The land is easily worked, and it absorbs and retains more moisture than most soils because of its favorable characteristics.

DARK SOILS WITH FRIABLE SUBSOILS

The dark soils with friable subsoils are rated among the very best and most desirable soils of the county. This group includes Canadian sandy loam and Canadian silty clay loam, which occur on second bottoms, or terraces. Owing to their dark color, comparatively high content of organic matter, and generally low-lying position, these soils are very absorptive and retentive of moisture. The loose friable and permeable subsoils allow rapid downward movement of water. The roots of deep-rooted plants easily penetrate the permeable subsoils and substrata. These characteristics are especially favorable for the production of corn, alfalfa, sorghums, and orchard crops, as well as vegetable, small-fruit, and truck crops. These soils are utilized largely for the production of corn in the open areas; and near homesteads, especially where protected by groves of cottonwood trees, small fruits, garden vegetables, and orchard crops are grown.

Canadian sandy loam.—Canadian sandy loam occurs on the second bottoms, or terraces, lying from 5 to 15 feet above the bordering first bottoms. It occurs along all the principal rivers and creeks, mainly along the upper part of Chikaskia River and Sand Creek in the southwestern part of the county. The total extent is small, but this is one of the most desirable soils in the county.

The topsoil of Canadian sandy loam consists of dark-brown or dark grayish-brown sandy loam which, in places, grades to almost loam. In most places the soil material contains enough clay to make it slightly sticky when wet. Below a depth ranging from 12 to 18 inches the topsoil grades into dark-brown or brown heavy loam

or clay loam. At a depth ranging from 24 to 30 inches the material is friable brown or rust-brown clay loam or sandy clay, which, with increase in depth, grades into brown or light-brown friable sandy clay that is more or less variable both in color and content of sand. Some lime concretions are present below a depth ranging from 2 to 3 feet.

Owing to the smooth but slightly sloping relief and the generally friable subsoil, all the run-off from the higher bordering upland slopes is readily drained away or absorbed. The well-drained condition of this soil allows cultivation of practically all of it. The prevailing sandy substratum favors a generally high ground-water level, and the position of this soil in valleys affords considerable protection to the growing crops against strong winds. The dark color indicates a liberal supply of organic matter, and the texture renders the soil suitable for easy working. Corn is the most important crop, and considerable kafir and alfalfa are produced. Some wheat and oats are grown, but the danger of lodging causes these crops to be rather uncertain. Acre yields of corn range from about 20 to 50 bushels, wheat 12 to 35 bushels, kafir 20 to 45 bushels, and alfalfa one-fourth to three-fourths ton at each cutting with the usual three or four, sometimes five, cuttings during the season. Vegetables, as potatoes, cabbage, onions, and beans, are grown very successfully, and small fruits, as strawberries, raspberries, blackberries, and grapes, are well suited to this soil. Orchard fruits, especially apples and cherries, succeed better than on most upland soils.

Canadian silty clay loam.—In position, color, friability of subsoil, and available moisture content, Canadian silty clay loam is like Canadian sandy loam. It differs from that soil mainly in its heavier texture. A few areas, however, have a more silty texture and suggest the reworking of the upper slopes of Albion silt loam and the modification, in part, of this soil by colluvial material. Corn and alfalfa are the chief crops. Yields of the various crops are about the same as those produced on Canadian sandy loam.

LIGHT-COLORED SOILS WITH FRIABLE SUBSOILS

The light-colored soils with friable subsoils include several soils of the Pratt and Grant series, and Vernon very fine sandy loam. This group comprises a smaller proportion of cultivated land than any foregoing group of arable soils. Because of the very sandy character of these soils, drifting in windy seasons is very menacing to growing crops and is extremely difficult to control. This explains why only about 60 or 65 percent of these soils is under cultivation. The low supply of organic matter does not provide growing crops the proper amount of plant nutrients for good yields, and it is mainly for this reason that these soils are not so high in agricultural value as are the arable soils in the other groups. Approximately 40 percent of the cultivated land is devoted to corn, 30 percent to sorghums, 20 percent to wheat, 6 percent to oats, 2 percent to legumes, and 2 percent to miscellaneous crops.

Vernon very fine sandy loam.—The most extensive areas of Vernon very fine sandy loam are in the south-central part of the county in the vicinities of Rago and Spivey, and a few smaller areas

lie south and east of Kingman. Geologically this soil has developed from the Permian "Red Beds" formation, outcrops of which begin southwest of Kingman and northeast of Zenda.

The 8- or 10-inch topsoil consists of reddish-brown loam. The sand grains are very fine, and in many places the texture grades toward very fine sandy loam. In many places the shaly material is so near the surface that the texture approaches silty clay loam. At a depth ranging from 10 to 18 inches the soil material is reddish-brown or red silty clay loam or silty clay, grading, at a depth of about 26 inches, into platy or shaly red silty clay loam or silty clay, containing an appreciable quantity of very fine sand. The depth to the shaly consolidated material is variable, ranging from 20 inches to 3 feet. Where this material occurs at the greater depths, the color in general is darker and the slopes more gentle, and such soils are correlated as Renfrow soils.

The relief ranges from undulating to sharply sloping. Owing to its generally slight depth and to its erosive, as well as droughty, character, only about 50 percent of the total area of this soil is under cultivation. The cultivated land is cropped chiefly to corn, wheat, kafir, sorghums, and alfalfa. Acre yields of corn range from about 18 to 35 bushels and of wheat from 10 to 20 bushels, but alfalfa yields are lower than those produced on the Woodward soils because of the nearness to the surface of the underlying impermeable shaly material. All this soil could be cultivated, but more or less difficulty would be experienced in the drifting or blowing of the topsoil. Corn and several varieties of sorghum seem to be grown as generally on this soil as are the small-grain crops. A higher content of organic matter would greatly improve the soil.

Pratt loamy sand.—Pratt loamy sand ranks next to Pratt sand in content of sand. Although this soil is not very important agriculturally, it occupies fairly extensive areas in the northwestern, southwestern, and southeastern parts of the county.

This soil is similar in some respects to Grant loamy sand, but it differs from the Grant soil mainly in that it does not contain gravel in the subsoil. The surface layer, to a depth ranging from 6 to 10 inches, is composed of brown, grayish-brown, or rather dark brown loose incoherent loamy sand which grades into reddish-brown loamy sand. In most places the subsoil, below a depth of 12 inches, is grayish-brown, yellowish-brown, or reddish-brown loamy sand which is somewhat sticky when moist but is always porous and friable. A body of soil, included with this soil in mapping, occurs in the northern half of secs. 13 and 14, T. 27 S., R. 7 W. The soil in this area consists of reddish-brown loamy sand or sand, apparently colluvial soil material washed from the higher slopes of Vernon loam. This included soil is slightly more productive than the typical soil. Because of its low content of organic matter, the productivity of Pratt loamy sand is not high. When the ground is once broken, shifting of the surface soil by wind action causes considerable variation in the quantity of sand in the topmost layer, or plow soil. Even before the ground was broken the broad gently sloping relief was characterized by numerous local variations resembling broad wavelike swells, or rather hummocky or billowy areas, which indicated that wind action played an important part in the formation of the original soil material.

About 40 or 50 percent of the total area of this soil remains in pasture. The more common grasses are big bluestem, broomsedge, Indian grass, sandgrass, and needlegrass. The grazing value of the land is a little higher than that of Pratt sand or Grant loamy sand and about equal to that of Pratt loamy sand, rolling phase. Corn, various sorghums, and wheat are the main crops grown. Corn yields range from about 15 to 20 bushels an acre, and wheat yields from 8 to 12 bushels. Only a small acreage is devoted to wheat, owing to the susceptibility of the crop to severe injury by wind-blown sand. Sweetclover and Sudan grass are well suited to this soil, and, in the lower situations, alfalfa usually succeeds. In the southeastern part of the county are several fairly large groves of catalpa trees which are grown for fence posts. These trees do very well and can be planted advantageously on the more sandy areas which have long been under cultivation. Cottonwood trees attain a great height, and some are several feet in diameter. Orchard fruits, such as cherries, plums, peaches, and apples, do well where protected by cottonwood groves.

Pratt loamy sand, rolling phase.—The rolling phase of Pratt loamy sand occurs only in the southwestern part of the county west of Nashville. The sand content of this soil seems to be slightly greater than that of typical Pratt loamy sand, and the sand grains average smaller, approaching fine sand. This texture, which renders the surface soil susceptible to movement by the wind, may account for the extremely hummocky or rather sharp hilly surface configuration and, perhaps, in places, to the deposition of all the soil material.

Soil of this phase differs from typical Pratt loamy sand, in that the color of the subsoil and substratum is more uniformly rust brown and that the soil material is more sticky when moist or wet. The topmost layer, averaging about 6 inches in thickness, is brown loamy sand which grades into rust-brown loamy sand of uniform texture, continuing to a depth ranging from 20 to 24 inches. Below this depth the color is a little lighter brown or reddish brown. In depressed areas the reddish-brown material may be splotched with lighter brown.

Approximately 50 percent of the land is cultivated. Corn occupies about 80 percent of the cultivated acreage, and the rest is planted to wheat and sorghums. Even with the low content of organic matter and shortage of rainfall, this soil produces a fair yield of corn, ranging from about 12 to 20 bushels an acre. When wheat is grown, the lower areas are most favored, because of less danger of drifting.

Pratt loamy sand, gray phase.—Pratt loamy sand, gray phase, is not extensively developed. The principal areas are north and northwest of Kingman. The relief in most places is very gently undulating, with a slight slope toward small drainageways. The position of this soil on lower slopes has prevented good underdrainage, and, although drainage of the surface soil is fair, continuous seepage from higher land during excessively wet periods has resulted in a rather grayish brown soil. This soil differs mainly from typical Pratt loamy sand in its more gray surface soil and lower subsoil layer and in having a comparatively higher content of fine sand in the soil material at all depths.

The topsoil, to a depth ranging from 10 to 14 inches, is grayish-brown loamy sand containing a comparatively high percentage of fine

sand grains. Below this the soil material contains some clay which imparts a slightly sticky feel when the soil is wet. This layer grades, at a depth ranging from 20 to 24 inches, into light-brown or light grayish-brown loamy sand and this, at a depth ranging from 36 to 40 inches, into light grayish-brown sandy loam or friable sandy clay material.

Probably 85 percent or more of this land is cultivated. Corn, kafir, Sudan grass, and other sorghums are the more important crops. Because of the susceptibility of the soil to drifting, wheat is not so well suited. Very large quantities of Sudan-grass hay and sorghum cane can easily be grown, furnishing an abundance of roughage for livestock. This soil is considerably better than the average of the soils in this group and is of about the same agricultural value as the soils in the group of light-colored soils with moderately heavy subsoils.

Grant loamy sand.—Grant loamy sand is not extensive and is of little agricultural importance. The larger areas occur in the northwestern part of the county along the lower slopes of small drainage-ways emptying into South Fork Ninnescah River. Apparently the soil material has been formed by the reworking and weathering of sedimentary material, and the occurrence of this soil along lower slopes near drains indicates that the material is colluvial in origin. A few areas in the southern part of the county near Rago resemble second-bottom or terrace land. These areas contain a higher percentage of gravel in the lower part of the substratum and probably were formed, at least in part, from sediments deposited during high overflows. When once broken this soil is very susceptible to drifting.

The topsoil consists of a 10- or 12-inch layer of brown loamy sand underlain by lighter brown loamy sand. At a depth of 18 or 20 inches, this material grades into grayish-brown or light-brown loamy sand or, in places where the material of the subsoil is heavier, into slightly reddish brown sandy clay. Considerable gravel occurs in the lower part of the subsoil, but it is not so abundant as in the subsoil of Grant sandy loam.

Approximately 50 or 60 percent of this land is cultivated. Because of the sandy and droughty character of the soil, its agricultural possibilities are very limited and the value low. Corn, kafir, and various grain sorghums are the more common crops, and yields are not high. From 10 to 20 bushels of corn and 8 to 12 bushels of wheat an acre are about all that can be expected unless plenty of rain falls when most needed.

Grant loamy sand, shallow phase.—The shallow phase of Grant loamy sand covers a small total area and is associated closely with the Woodward and Vernon soils. The soil material in most respects is similar to that of typical Grant loamy sand, but, owing to the position of this soil on lower slopes bordering the Vernon and Renfrow soils, considerable reddish-brown colluvial material is intermixed with the loamy sand, imparting a red tint. A few areas bordering the Arkansas soils of the bottom land apparently have been deposited during high overflows in the past and are second-bottom soils but, owing to their small extent, are included on the soil map with this soil. These shallow areas are also intermixed with colluvial wash

from the higher lying Vernon and Renfrow soils which impart a red tint to the loamy sand material.

This shallow smooth soil has a smooth slightly sloping relief. Both surface drainage and underdrainage are good, and the land is more productive than typical Grant loamy sand. Practically all the land is cultivated, mainly to corn, alfalfa, and wheat. The prevailing high ground-water level assures more moisture during dry periods, which results in higher yields than those obtained on typical Grant loamy sand.

Grant loamy sand, imperfectly drained phase.—Grant loamy sand, imperfectly drained phase, does not cover a very large area. The largest body lies about 2 miles northeast of Cunningham. This soil occurs on low slopes bordering the Arkansas soils of the first bottoms, at considerably lower levels than the bordering Grant sandy loam.

The topsoil consists of a 10- or 12-inch layer of grayish-brown loamy sand grading toward sandy loam. It is underlain by gray sandy loam. At a depth ranging from 18 to 24 inches the material is light grayish-brown friable sandy clay containing some rusty-brown and yellowish-brown mottlings. This soil is similar to Grant loamy sand, gray phase, except that, owing to underground seepage, a considerable part of it is wet throughout the year. The poorly drained areas are indicated on the soil map by marsh symbols. Some of the drier areas can be cultivated, but only about 50 percent of such land is under cultivation, the rest being left as pasture land or hay meadow. The better drained areas are usually cropped to corn, sorghum, or kafir, and yields are better than those produced on typical Grant loamy sand. The areas indicated on the soil map by marsh symbols support a cover of water-loving grasses.

Pratt sand.—A few areas of Pratt sand occur about 3 miles northwest of Nashville, 5 miles northwest of Kingman, and in the southeastern part of the county. The relief is hummocky or billowy, local differences ranging from about 2 to 6 feet. Because of the very sandy character of this soil and its susceptibility to blowing and drifting, the kinds of crops grown are limited in number, and in many years yields are very unsatisfactory.

Possibly about 50 percent of this soil is under cultivation. When conditions are favorable, 15 bushels of corn an acre is a good yield. Kafir and other grain sorghums, especially Sudan grass, are the more commonly grown crops. The plowable grazing areas will support about 5 head of cattle on 40 acres. Stipa, or needlegrass, sandgrass, and some big bluestem are among the more common pasture grasses.

SOILS OF THE STREAM BOTTOMS

The soils of the stream bottoms are comparatively unimportant, both in acreage and agricultural value. Because of their susceptibility to occasional overflow, to wind drifting when broken, and, in many of the low-lying situations, to continuous poor or imperfect drainage, a high proportion of these soils is necessarily utilized for pasture and hay land. These soils border streams which afford excellent clear water, making them valuable to the livestock farmer. In most places a fringe of cottonwood trees, or at least a few scat-

tered trees, provide shade for livestock. The better drained bottom land is used largely for cultivated crops, mainly corn, sorghums, and alfalfa. The water table is everywhere within 10 feet of the surface, in many places much nearer, and the lower parts of the subsoils are kept well supplied with moisture, even during droughty periods. Small grains have a tendency to lodge. Orchard fruits and vegetables yield well on the better drained sandy loam areas.

Arkansas loamy sand.—Arkansas loamy sand is mapped on the first bottoms of South Fork Ninescah and Chikaskia Rivers and many of the smaller creeks and drainageways where sandy soils occur. Most of this soil lies from 3 to 6 feet above the normal water level of the streams, and, owing in part to overflows, many areas close to the streams are rather hummocky, and they range in texture from loamy sand to sand. All these areas are included with this soil as mapped because of their slight agricultural importance and small extent.

Arkansas loamy sand has a surface soil of light-brown or grayish-brown loamy sand. This grades, at a depth ranging from 10 to 15 inches, into gray or grayish-brown loamy sand or sand. At a depth ranging from 3 to 5 feet, the substratum is considerably spotted with pale-yellow or decidedly grayish yellow material.

Owing to its very sandy character, only about 10 percent of the total area of this soil is cultivated. When the land is once broken, the sandy texture of the surface soil makes it susceptible to serious drifting by wind. Corn produces fair yields in occasional seasons of unusual rainfall, but the acreage devoted to this crop is very small. Some wheat and sweetclover are grown, and a fair stand of alfalfa may be obtained in areas bordering the Renfrow and Vernon soils.

Arkansas sandy loam.—Arkansas sandy loam, which occurs along the larger stream and creek bottoms, differs from Arkansas loamy sand in that it occupies comparatively higher positions, is less subject to overflow, and has a much higher content of organic matter, which renders the soil less susceptible to drifting when the land is brought under cultivation. Owing to the prevailing high ground-water level, this soil supports an excellent growth of wild grasses. Several areas lying adjacent to a number of upland soils receive more or less seepage water from the higher land, and drainage of these areas is so poor that they can be used only for hay and pasture.

Approximately 30 percent of the total area of Arkansas sandy loam is cultivated, although most of this soil can be cultivated if adequate drainage is provided. The crops grown are corn, kafir, Sudan grass, alfalfa, and sweetclover. Acre yields of corn range from about 15 to 40 bushels. Owing to their tendency to lodge, a comparatively small acreage is cropped to small grains. Because of the scarcity of good grassland much of this soil is kept out of cultivation.

Most of the areas along Painter Creek, however, are cultivated. The soil here consists of dark grayish-brown sandy loam, ranging from 8 to 12 inches in thickness, which grades into grayish-brown heavy sandy loam or clay loam. The subsoil, at a depth ranging from 15 to 20 inches, is grayish-brown sandy clay, more or less mottled with gray and rust brown, which in many places grades into heavy loam or clay loam. In areas closely associated with Arkansas loamy sand the subsoil, at a depth ranging from 20 to 24 inches, is

grayish-brown sand, sandy loam, or clay loam material with little uniformity in texture at different depths.

Arkansas clay loam, poorly drained phase.—Arkansas clay loam, poorly drained phase, is similar to Arkansas sandy loam, except that both the topsoil and subsoil contain a higher percentage of clay, and the topsoil in general is darker gray and contains considerable organic matter. The subsoil grades into gray, brown, or grayish-brown clay loam, and sand is more abundant in the lower part.

This soil occurs in a few medium-sized areas along the two rivers, mainly in the western half of the county. Practically all of it is utilized only for pasture, because of its rather imperfect drainage and the difficulty experienced in keeping the soil in good tilth when under cultivation.

Yahola sandy loam.—Yahola sandy loam is a very inextensive soil. It occurs along Rose Bud Creek north of Rago and along a branch of Sandy Creek in the southeastern corner of the county. This soil is derived largely from the red upland soil material of Renfrow clay and Vernon very fine sandy loam, intermixed considerably with wash from the sandy material of the associated Grant soils. Although susceptible to occasional overflow, the land is cropped mainly to corn which produces good yields. It is well suited to alfalfa. Crop yields average higher than those obtained on the Arkansas soils.

MISCELLANEOUS LAND TYPES

The group of miscellaneous land types includes all bodies of soils, which are too steep, gullied, or shallow to allow cultivation and in their present condition can be utilized only for grazing. These soils include both dune-sand areas and excessively eroded land derived from several distinct parent materials. The soils derived from the Permian "Red Beds" soil material contain liberal quantities of unleached lime and are sufficiently heavy in texture to support a better and more nutritious growth of grasses than the extremely sandy soils.

Albion sandy loam, broken phase.—The broken phase of Albion sandy loam includes all areas of that soil, which are too steep, sandy, excessively eroded, and cut by deep ditches to allow cultivation. The occurrence of such areas is restricted to numerous narrow belts bordering the heads of drainageways which terminate abruptly near the ridge crests or the brows of the upland divides. Such areas are most common in the western part of the county, mainly along the slopes of Allen Creek and Sand Creek. They ordinarily occur at lower levels than do the associated heavy-textured soils with similar relief. Near the drainageways the surface soil is underlain by red sandy clay similar to that in the lower layers of typical Albion sandy loam.

This soil supports a thinner stand of grasses than that on the eroded areas of the heavy-textured soils. Various kinds of sand-grass, sand-hill plum, and weeds are mixed with some of the more common native grasses which grow on the more sandy land. In places where the land has been overgrazed, barren blown-out spots occur; and a few areas are rather hummocky. Ordinarily it requires

8 or 10 acres of this land for each grown steer, and in dry seasons the land is likely to be overgrazed.

Vernon clay, broken phase.—The broken phase of Vernon clay occurs within areas of the Vernon soils, which have been eroded until the land is too rough and gullied to be used for cultivated crops. The red sandy clay is exposed on the hillsides. In places there is a thin covering of the surface soil, and here the texture may be loam or sandy loam. This covering in most places is thin, however, and the greater part of the surface soil has a heavier texture.

This soil occurs in irregular-shaped bodies, most of which are along the slopes of South Fork Ninnescah River west and south of Murdock. In most places it occupies the slopes immediately below the comparatively level upland.

The surface of this soil is so choppy and dissected by gullies that cultivation is impossible except on a few small patches which have escaped excessive erosion. About 60 percent of the total area of this broken land supports a growth of grasses, and the rest is bare. The grasses are more nutritious than those growing on the broken phases of the sandy soils, and the land will carry more livestock without danger of overgrazing. On account of its large proportion of bare surface this land does not have a high value for grazing.

Rough broken land (Vernon soil material).—A number of severely eroded areas, in which little or no soil development has taken place, are shown on the map as rough broken land (Vernon soil material). Small bodies, in which a normal surface soil has developed, have the general characteristics of the Vernon soils. The color ranges from brown to rather dark grayish brown, and the texture in most places is either loam or clay loam. The underlying material, which is exposed in many places, is brown or reddish-brown sandy clay. A small quantity of gravel is scattered over the surface and through the soil.

Soil of this phase occurs in narrow belts on slopes along the heads of drainageways and bordering the smoother upland areas. The distinguishing feature of these areas is their severely eroded surface soil.

Cultivation, except in a few small spots, is impossible, on account of the rough, gullied condition of the land. This land is used only for grazing. It supports a grass cover on about 60 percent of the area. The stand of grasses is more uniform than on the eroded sandy soils; and the grazing value of the grasses is higher. On account of the proportion of bare surface, from 6 to 8 acres are required to support a steer during the grazing season.

Pratt sand, dune phase.—The few areas of the dune phase of Pratt sand occur mainly in the southeastern part of the county on the bottom land along Chikaskia River. The dunes range from about 4 to 25 feet in height.

This soil consists of incoherent gray or grayish-brown sand or fine sand, containing a slight admixture of darker material in the topmost 2 to 4 inches, in places where some vegetation grows, but in most areas where the material has been recently shifted by the wind it consists of light-brown sand changing little with increase in depth. The sand ranges from medium to fine in texture and is apparently wind-blown material of the bottom land or, possibly, comes from the sandy upland slopes of Tertiary origin.

A little vegetation grows in places, mainly at the lower levels where more moisture is available. This land supports a few scattered trees and bushes and a scant growth of rather coarse grasses which are of little grazing value. All the land is utilized for pasture.

AGRICULTURAL METHODS AND MANAGEMENT

The net income of any farmer is governed very largely by the way he manages his farm. Every farmer should strive to utilize his particular kind of land to the best advantage and at the same time not allow it to deteriorate in productiveness. To this end the best of judgment is required, and a knowledge of soils, machinery, crops, and livestock is necessary, in order to attain the best results.

Crop yields can be maintained at either a high or a low level, depending on treatment and management of the soils, and success depends largely on the farmer's knowledge and skill in applying the proper cultural methods, or system of management, for his particular soil or soils. One of the important problems is to conserve and utilize to the best advantage the comparatively low amount of rainfall. The farmer who begins turning under wheat stubble immediately after the crop is harvested, invariably conserves a higher percentage of moisture in the soil than do those who wait until late summer or fall to do their plowing. In this locality considerable time is necessary to bring about the proper decay of either wheat stubble or green-manure crops before the succeeding crop is planted. A smaller percentage of noxious weeds goes to seed if plowing is done immediately after harvesting, and, even if rains start a new crop of weeds, a light harrowing or disking not only will eliminate them but will put the land in better condition for the succeeding crop.

Summer fallow is practiced by some farmers in this county. About 1,640 acres were lying fallow in 1932, and only 510 acres were in small grains. Ordinarily this practice is unnecessary, unless the spring and early-summer moisture supply is so limited that sorghum crops are not likely to make good yields.

As a rule, the soils are fairly absorptive and retentive of moisture, but continual cropping without legumes or grasses in the rotation gradually depletes the soil of its valuable supply of organic matter, and on the more sloping areas erosion is accelerated, thereby still further increasing the run-off and diminishing the amount of water absorbed by the soil. Many of the soils which have been under cultivation for 30 or 40 years have been depleted of one-third or more of their original supply of organic matter. This situation is disregarded by most farmers who produce small grains, and many of them have not noticed any serious decline in yields. On the other hand, corn, which requires much more organic matter and nitrogen than wheat, has shown a marked decrease in yields. Moreover, practically all the desirable land for growing corn has long been under cultivation, and the additional new land brought under cultivation during the World War was utilized largely for growing wheat, thus offsetting the true average decline of wheat on fields long under cultivation.

The continuous growing of wheat year after year on the same land, has depleted the soil not only of organic matter and nitrogen,

but also of other valuable plant nutrients. The available supply of phosphorus and potash in the soils has been lowered very considerably, and, inasmuch as phosphorus is one of the more important plant nutrients of wheat, this constituent must be supplied in some form or other. Commercial fertilizers have not been generally used, as their use has not proved very satisfactory, owing to the light precipitation in this locality. Should the season be dry, the results due to their use are negligible, and most farmers are inclined not to risk the extra expense involved when results are so uncertain.

Diversified farming, therefore, seems to be the most practical way of restoring a more adequate supply of plant nutrients in the soil. This type of agriculture not only requires the growing of grain sorghums, sweetclover, and other hay and forage crops, but stimulates the production of more livestock and poultry and their products. This practice makes possible the turning under of some leguminous pasture crops each year, in addition to the application of barnyard manure on other fields, with a benefit to both fertility and tilth. Such a type of agriculture is not only more dependable in producing good yields of crops, but the productivity of the soil is maintained at a much higher level than when the land is consistently cropped to the chief cash crop, wheat. Up to the present time no cropping system has been followed in which legumes are grown each year and some crops turned under primarily for soil-improvement purposes. Sweetclover, however, is increasing in acreage and probably will be grown more extensively in the future.

Forage crops are produced for roughage, grain, or silage and are fed locally. Kafir, the leading forage crop, fits well into the feeding ration, furnishing an abundance of coarser materials which may be fed with grain. Because it succeeds well on land where other crops are uncertain, it is a very desirable crop. Even though the grain is slightly inferior to corn in nutritive value, this objection is more than offset by the greater and more sure acre yield. Many farmers prefer Sudan grass and sorgo, and if such crops are fed with some alfalfa hay the results are equally as good, if not better, as shown by experiments at the Hays experiment station.

Farm-management practices and the methods used in growing and harvesting crops in this county are similar to those throughout southwestern and central Kansas. The most modern machinery is used in the farming operations. The most common practice of planting corn on the sandy upland and alluvial land is by listing, as, by this method, the sandy soils are less susceptible to drifting, and corn so planted is considered by most farmers to be more drought resistant than surface-planted corn. A few farmers, however, mainly those who farm the heavier soils, plant corn in checkrows and cultivate both with and across the rows. The crop receives two or three cultivations and ordinarily is laid by during the first part of July. After the crop matures in September or October, the corn is husked, and livestock are pastured in the fields during the winter. Many farmers cut the corn crop for silage, others cut and shock the stalks to be used for winter roughage, and a few fence off a few acres for turning in either feeder cattle, sheep, or hogs, thereby saving a part of the expense of husking the crop.

Land to be used for wheat is usually plowed early, harrowed in late summer, and seeded with a press drill the early part of October,

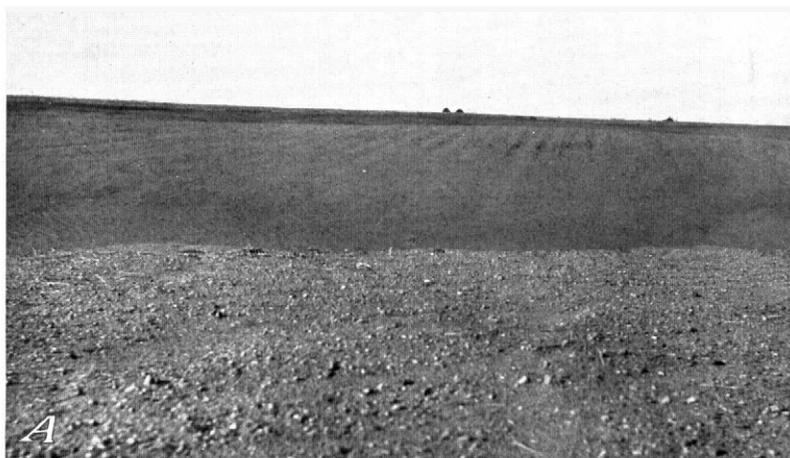
in order that the crop may make a fair growth before killing frosts occur and yet be late enough to escape injury by the hessian fly.² Livestock are sometimes turned in and allowed to graze for a time during late fall, early winter, or early spring, when weather conditions are favorable, provided the stand is unusually good. The crop ordinarily matures during the latter part of June and is cut with a binder, a header, or a combine.

The blowing and drifting of soil in old plowed fields (pl. 3, *A*), especially the sandy soils, is causing more and more concern. Therefore, plowing of the more sandy soils is ordinarily delayed until a short time before seeding the subsequent crop, in order to prevent excessive drifting. During very droughty periods, barren plowed fields, even of rather heavy soils, are becoming more and more susceptible to wind blowing because of the gradual loss of organic matter in the topsoil, and occasionally dust storms carry quantities of the fine silt particles to a distance of hundreds of miles. The sandy soils lose much of their finer particles, and the coarser sand particles blow across the fields, forming massive drifts along fence lines and at other obstructions, and, where these coarse sand grains blow over a small-grain crop only 2 or 3 inches high, the crop may be severely injured if not totally destroyed. This danger from wind erosion is almost as significant as that from water erosion on the sloping lands, and the retention of all available moisture, whether in the form of rain or snow, is of utmost importance in minimizing this danger.

The effects of water erosion (pl. 3, *B*) on the older sloping fields which have been poorly managed is apparent. Even under an average yearly rainfall of only 29 inches, soil erosion is a serious danger on the sandy sloping soils, and, although the total area of soils decidedly susceptible to erosion is not large in this county, erosion is sufficient to cause some concern. Only a few farmers have constructed terraces. The prevailing practice of planting corn without regard to slope has greatly accelerated erosion in sloping fields, and many severely gullied slopes are in evidence. The gradual washing away of the darker topsoil, with its valuable supply of organic matter and nitrogen, and the mixing, through plowing, of the heavier underlying subsoil, cause these soils to be less permeable to air, moisture, and crop roots, less absorptive and retentive of moisture, and much less productive, and the tilth is generally impaired. Heavy applications of manure or the frequent turning under of leguminous crops ordinarily restore the productive capacity to a great extent, but such efforts are of only temporary value unless provision is made for a system of crop rotation adapted to the land.

Terracing, supplemented by contour farming, is one of the most dependable methods of stopping wastage from erosion on cultivated land. The broad-based terrace is best suited to most of the sloping land in need of terracing. Even on more gentle slopes, broad-based terraces with little or no gradient are very effective in decreasing the run-off and in increasing the supply of moisture in the soil for succeeding crops. The conservation of moisture is, and always has been, of paramount importance in any locality having a low rainfall, where intertilled crops are grown. Destructive gullying is pre-

² SALMON, S. C., and THROCKMORTON, R. I. WHEAT PRODUCTION IN KANSAS. Kans. Agr. Exp. Sta. Bull. 248, 84 pp., illus. 1929.



A, Soil drifting on Albion sandy loam where the land is not properly managed to prevent soil blowing.
B, Severely eroded barren strip bordering an upland drainageway. Special care must be taken to prevent erosion, and ordinarily such strips should be devoted to grass.

vented so long as the terraces are properly maintained, a much higher acre yield can be obtained by intelligent cropping or soil-improvement practices, and the land, under normal conditions, has a fixed rather than a gradually declining value.

A complete system of erosion control should include a cropping system that will keep the land covered with leguminous crops and grasses a large part of the time, and the row crops should be planted lengthwise with the terraces, in order to reduce erosion to a minimum. Inasmuch as terracing has been the most dependable means of checking disastrous soil erosion in all the Southern States, even prior to the Civil War, the merits of this method are thoroughly understood, and this means of conserving not only the richer topsoil but, in this locality, a much higher percentage of moisture is of great importance.

The steeper slopes should be seeded to grass for a permanent sod. Such grasses as brome grass, little bluestem, big bluestem, and the grammas may be used successfully if seeded during late summer, as the latter part of August, on well-prepared soil that contains an abundance of moisture.

MORPHOLOGY AND GENESIS OF SOILS

The most fully matured and normal soils of Kingman County are not extensive. They belong to the group of Chernozem soils which extend north and south through the Great Plains region. They are, for the most part, formed from materials of Tertiary age, which in this region consist of an apron of debris extending eastward from the Rocky Mountains. In the south-central and east-central parts of the county this covering is absent, and a few comparatively small spots of the marine Permian formation of Kansas is exposed. These formations slope gently eastward, and Kingman County is a portion of a partly eroded plain, of which approximately 25 percent has been reduced below the original level by erosion. The materials involved consist of shales, clays, conglomerates, fine stratified sandstones, keel, gravel, and sands. The gravel and sands are outwash from the Rocky Mountains and consist mainly of granite and quartz materials.

The development of the different soils in this county is the result of the vegetation, as conditioned by climate and relief, acting on the different geological materials. Assuming that the several recent decades have been fairly representative of climatic conditions of the past ages, the soils have developed under an average annual rainfall of about 29 inches and an average annual temperature of 57.2° F. The soils have developed under a grass cover, the thickness and character of the stand having been influenced mainly by the climate, the degree of slope, and the texture and other properties of the parent material. The soils of the broad smooth upland divides have become stabilized and have a dark A horizon, indicating a high content of thoroughly decomposed organic material, whereas the very sloping or excessively sandy parts of the county have not produced so thick a stand of grasses, and the soils are, therefore, much lighter in color.

Under the prevailing rainfall, the carbonates have leached to only a slight depth. Ordinarily a slight accumulation of calcium car-

bonate occurs at a depth ranging from 30 to 36 inches in the more mature soils, but on sharp knolls and slopes, where the soil is very immature, carbonates are present in the form of small and large concretions, pockets, and highly concentrated zones of very light color. In places occupied by excessively sandy or gravelly material, lime is leached to a much greater depth, ordinarily from 5 to 7 feet.

The degree to which the climatic and vegetative agencies have acted on the parent soil materials is conditioned by the relief and drainage conditions under which the soils have developed. In this county differences in elevation are not great, but a number of steep sharp slopes occur in several sections. In such places, however, where the run-off is great, erosion apparently almost keeps pace with the slower weathering of the parent materials which give rise to the most immature or imperfectly developed soils. On the broad upland divides of mild relief, the normal erosion is slight and is equal to the rate of soil development. Here the soils have attained the maximum development under the prevailing native vegetation and climate and may be regarded as the normal soils for the area. The most extensive areas of these soils belong to the Albion series, of which Albion loam is the most important type. Following is a description of a profile of virgin Albion loam, heavy-subsoil phase, as observed in a dug pit along the road about 100 yards east of the section corner at Lone Star School and 4 miles east of Penalosa :

1. 0 to 6 inches, dark grayish-brown heavy loam grading toward clay loam in texture. The soil crumbles to a fine-granular structure. The granules range from one-thirty-second inch to one-sixteenth inch in diameter, and most of them are round or nearly so.
2. 6 to 10 inches, dark grayish-brown clay loam containing a moderate quantity of sand grains and a few small granitic pebbles. The structure is granular.
3. 10 to 14 inches, brown clay loam which is slightly lighter in color and heavier than the material in the layer above. The soil material is slightly acid in reaction, is coarse granular when dry and very sticky when wet.
4. 14 to 24 inches, the upper part of the layer of maximum density. The dark reddish-brown heavy clay contains a noticeable percentage of granitic and quartz sand grains and a few pebbles of like material. The material has a rather coarse blocky structure and breaks into vertical cubelike aggregates ranging from 1 inch to 1½ inches in diameter.
5. 24 to 36 inches, the lower part of the layer of maximum density. The material is lighter brown than that in the layer above and has a slightly red tint. The main cleavage planes are vertical, and the aggregates are rather cubelike and range from three-fourths inch to 1½ inches in diameter. The material is not easily separated at the cleavage lines, and the aggregates are compressed into large extremely hard chunks. When wet this material is very sticky clay loam or sandy clay, and it breaks into rather sharp coarse granules which are very irregular in shape and size.
6. 36 to 50 inches, light-brown or rusty-brown sandy loam. Small pebbles are scattered sparingly through this layer, but they increase in abundance, as does the sand content, with increase in depth.

Another dark soil, which may be regarded among the best developed soils, is Idana silty clay loam which occurs chiefly in a single body about 6 miles southeast of Cunningham. Following is a description of a profile of this soil, as observed on the west side of

the road about one-half mile south of Oklahoma School in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 2, T. 29 S., R. 10 W.

1. 0 to 7 inches, a dark grayish-brown silty clay loam with a faint sprinkling of minute gray specks. When crushed a lighter brown tint is visible, with no gray cast. The structure is fine granular. The topmost 1-inch layer has a rather poorly defined laminated arrangement. The material is slightly acid in reaction.
2. 7 to 15 inches, granular or fine-granular dark grayish-brown silty clay loam grading toward silty clay in the lower part. The material is slightly acid in reaction.
3. 15 to 22 inches, dark grayish-brown silty clay having a rather sharp angular granular structure. When dry the soil breaks out in compact blocks. The material is slightly acid or almost neutral in reaction.
4. 22 to 36 inches, dark grayish-brown heavy clay of maximum density, breaking into huge massive chunks when dry. A few lime concretions are noticeable in the lower part. The reaction of the soil material is neutral.
5. 36 to 60 inches, dull grayish-brown clay containing a small percentage of lime concretions. The material is less dense than that in the layers above. The material in the lower part of this layer is olive gray. The reaction is alkaline.
6. 60 to 70 inches, light olive-gray highly calcareous material containing numerous lime pockets or splotches. The reaction is alkaline.

In the east-central and south-central parts of the county the underlying geological formation known as the marine Permian is exposed, giving rise to the Vernon and Renfrow soils. Among the immature soils, Renfrow silt loam has reached the most advanced stage.

SUMMARY

Kingman County is in the south-central part of Kansas and has a total area of 860 square miles.

Physiographically, the county is part of a nearly flat plain moderately dissected. The greater part of the county is covered with soil material of Tertiary age consisting of outwash from the Rocky Mountains, and some alluvial deposits in the eastern half are of Permian age.

The general slope of the land is toward the southeast, but differences in elevation are small. Drainage is effected by North Fork Ninescah River, South Fork Ninescah River, Chikaskia River, and their tributaries. The county, as a whole, is well drained.

Elevations range from 1,840 feet above sea level on the western border to 1,340 feet in the southeastern part.

The population in 1930 numbered 11,644, of which 8,992 people were classed as rural.

Transportation facilities are provided by two railroads and many miles of well-kept graded roads. United States Highway No. 54, built of concrete, crosses the northern part of the county.

Public schools and churches are conveniently located. Rural delivery of mail reaches practically all farms, and many farms have telephone service.

The climate is temperate and suited to grain farming and livestock raising. The mean annual temperature is 57.2° F., and the mean annual rainfall is 29.33 inches. The average length of the frost-free season is 193 days. Occasional hot winds from the southwest sometimes injure the grain crops.

Corn, wheat, oats, and potatoes have always been the principal crops, but in recent years grain sorghums, legumes, and other hay and forage crops have been grown on greatly increased acreages. Dairying and livestock raising have increased.

The 1935 census reported 1,638 farms in the county with an average size of 320.2 acres, of which 72.9 percent was classed as land suitable for crops and plowable pasture.

The average value of land and buildings per farm in 1935 was \$10,705, and the average acre value of land, including buildings, was \$33.43.

Very little commercial fertilizer is used.

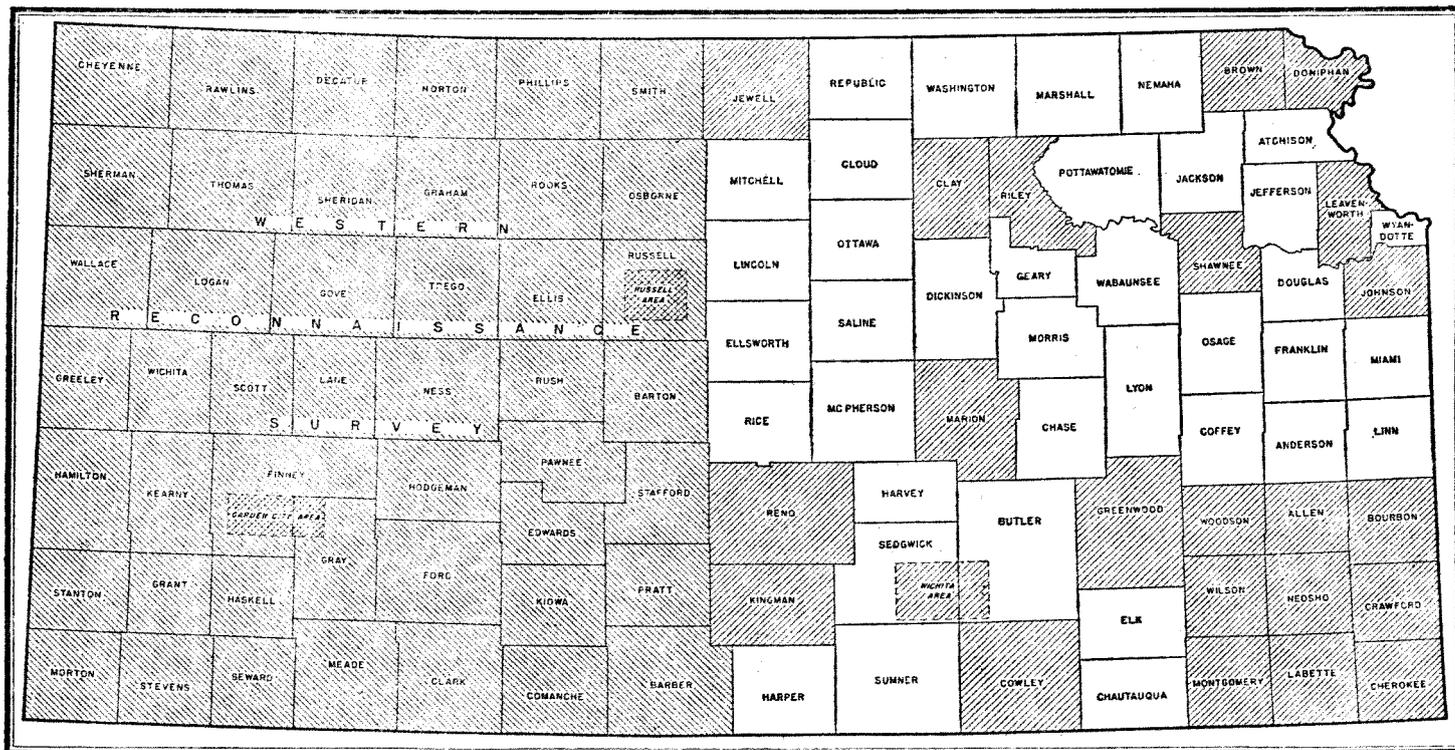
Dairying and cattle, hog, sheep, and poultry raising and fattening produce considerable income yearly.

The soils have been developed under a grass cover and a comparatively low rainfall. They belong with the Chernozem group of soils. Very little leaching of plant nutrients from the soils has occurred, and most of the soils are comparatively high in fertility. The moisture supply is the limiting factor in crop yields. The dark soils are the most productive and dominate the agriculture. The light-colored soils are less extensive, and crop yields on them do not average so high and are more uncertain than on the dark soils.

The upland soils are divided and discussed in the following three groups. Dark soils with heavy subsoils, dark soils with friable subsoils, and light-colored soils with friable subsoils. The soils of the stream bottoms comprise an inextensive group. A group of miscellaneous land types includes a few soils which have been so eroded and gullied or are composed of such loose sandy material as to be non-arable.

Authority for printing soil-survey reports in this form is carried in the Appropriation Act for the Department of Agriculture for the fiscal year ended June 30, 1933 (47 U. S. Stat., p. 612), as follows:

There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Kansas shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by north-west-southeast hatching; crosshatching indicates areas covered in both ways.

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